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ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

S. 1286

TO ESTABLISH A PROGRAM TO CONDUCT RESEARCH AND DEVELOPMENT FOR IMPROVED MANUFACTURING TECHNOLOGIES, AND FOR OTHER PURPOSES

NOVEMBER 23, DECEMBER 6 AND 7, 1983

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ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

WEDNESDAY, NOVEMBER 23, 1983

U.S. Senate,
Committee on Commerce, Science, and Transportation,
Subcommittee on Science, Technology, and Space,
Seattle, Wash.

The subcommittee met, pursuant to notice, at 1:30 p.m., in the Federal Building, South Auditorium, Seattle, Wash., Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Cheryl Coodley, professional staff member; and Bob Sneed and Steven Flajser, minority staff members.

OPENING STATEMENT BY SENATOR GORTON

Senator Gorton. Welcome to this afternoon's hearing on the role of advanced manufacturing technology in our Nation's ability to compete in markets at home and abroad. The health of the U.S. economy and the employment of our work force depend significantly on the strength of our manufacturing industries.

In 1981, manufacturing provided a quarter of our gross national product, accounted for more than one-fifth of all jobs, and produced $154 billion in goods for export. Our high standard of living and our national security have been due in large part to our ability to manufacture a wide range of goods superior to those of our foreign competitors.

But there are disturbing signs for our manufacturing industries. In the past 4 years, the number of manufacturing jobs has dropped by 3 million, and production of manufactured goods has fallen by 11 percent. Imports produced by foreign-based workers captured nearly 9 percent of the domestic market for manufactured goods in 1982, and are expected to capture a higher proportion this year. A negative balance of trade of $15 billion for manufactured goods is currently projected for this year.

In recent years, manufacturing technologies have advanced through introduction of technological innovation such as use of computer assisted design and manufacturing, automated machines and exotic sensors. Yet U.S. industries have been comparatively slow in adopting these innovations. For example, 31 percent of the manufacturing equipment used by U.S. industries is less than 10 years old, as compared to 60 percent of the manufacturing equipment of Japan.

Perhaps because U.S. industry has lagged in adapting new manufacturing technologies, our position as a technological innovator in the field is eroded. A National Academy of Engineering Panel, for example, reported earlier this year that the United States machine tool industry is beginning to lose its technological leadership to Japan and West Germany. This month a study by the Office of Technology Assessment on International Competitiveness in Electronics reported that although electronics in general remains a leader among American industries, competitiveness in consumer electronics products has declined precipitiously since the 1960's. Moreover, American semiconductor firms have been facing increasingly intense competition from Japanese manufacturers, and this trend can be observed in the computer industry, as well.

There are many elements in the effort to remain competitive, including education and training of engineers, technicians, and skilled workers to handle a strong technological base. But the efforts of the Federal Government, the universities and industries to advance our manufacturing technologies and train the associated skilled work force have been limited and fragmented.

With regard to our technological base, we have been told that there are significant gaps in our research; research which is essential for achieving a technological advantage in manufacturing. Additional research has been called for in such areas as visual and tactile sensors, machine control and communication strategies and human machine interfaces, and sensory information processing.

Our universities, traditionally a major source of scientific and technological innovaton, are much less involved in manufacturing then in other fields of engineering. We have been able to identify only a half dozen universities with strong research and training programs in manufacturing engineering, a narrow base indeed, for the extent of technological innovation needed to remain competitive.

Yet the world may well be encountering a revolution in manufacturing as great as that brought about by Henry Ford's adaptation of the assembly line. Those industries and countries able to develop and use advanced manufacturing methods will have competitive advantages over the rest of the world.

Today we will her testimony on the role of technology in competitiveness and on a bill which I have introduced and which is cosponsored by a bipartisan group of Senators, to provide national funds for industry, universities, State and local governments interested in cooperating in research into advanced manufacturing methods as one means of building our technological base and strengthening our universities. We will hear from industry and university leaders in three panels.

[The bill follows:]

II

98TH CONGRESS
1ST SESSION

S. 1286

To establish a program to conduct research and development for improved manufacturing technologies, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MAY 16, 1983

Mr. **GORTON** (for himself, Mr. **GOLDWATER**, Mr. **TRIBLE**, Mr. **HEFLIN**, Mr. **RIEGLE**, Mr. **LAUTENBERG**, and Mr. **TSONGAS**) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

---

A BILL

To establish a program to conduct research and development for improved manufacturing technologies, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Manufacturing Sciences and Technology Research and Development Act of 1983".

FINDINGS

SEC. 2. The Congress finds that—

(1) various sectors of private industry, the Federal Government, and the United States research establishment have not devoted sufficient attention to research

on developing new processes and methods to improve the Nation's capability to manufacture goods;

(2) while manufacturing industries are essential to the economic well-being of the Nation, many manufacturing processes and methods are no longer capable of producing goods as reliable and cost-competitive as those produced by foreign industries which utilize modern manufacturing methods and processes;

(3) domestic manufacturing is increasingly threatened by external competition and the development by foreign countries of more efficient manufacturing processes and technologies;

(4) outdated manufacturing methods and processes result in higher costs and goods and services of inferior quality, which place great burdens on consumers of such goods and services;

(5) outdated and inefficient manufacturing processes hinder domestic commerce;

(6) transportation and delivery of manufactured goods are vital components of the Nation's interstate commerce, and a decline in consumption of domestic manufactured goods due to inefficient manufacturing processes produces a resultant decline in transportation;

(7) manufacturing contributes large amounts of revenue to the Nation's gross domestic product and employs more than one-fifth of the Nation's work force;

(8) domestic manufacturers have not sufficiently utilized such recent technological changes in manufacturing as programable automation, robotics, advanced sensors, and computer-assisted design and manufacturing; and

(9) a program to conduct research which will produce more efficient manufacturing processes and methods and to encourage research utilization would strengthen commerce and be beneficial to the Nation's consumers.

PURPOSE

SEC. 3. It is the purpose of this Act to establish a program for conducting research which will produce more efficient manufacturing technologies and for conducting research utilization activities to encourage widespread adoption of these technologies.

DEFINITIONS

SEC. 4. As used in this Act, the term—

(1) "Advisory Committee" means the Manufacturing Sciences and Technology Enhancement Advisory Committee established under section 8 of this Act;

(2) "consortia" means a group of organizations such as States, individual industries or industry associations, nonprofit research institutions, and universities and other academic institutions;

(3) "Center" means a Center for Manufacturing Research and Technology Utilization established under section 5(c) of this Act;

(4) "Office" means the Office of the Assistant Secretary for Productivity, Technology and Innovation within the Department of Commerce; and

(5) "Secretary" means the Secretary of Commerce.

GRANTS AND COOPERATIVE AGREEMENTS

SEC. 5. (a) PURPOSES.—The Secretary, through the Office, may award grants and enter into cooperative agreements in accordance with the provisions of this section to provide for research on methods of producing more efficient manufacturing processes and methods, including—

(1) computer-assisted design;

(2) automated materials handling, processing, and assembly;

(3) automated testing;

(4) machine adaptive learning;

(5) integrated manufacturing systems, including interface of automated machines with automated and

nonautomated machines, with production and design personnel, and with other systems (including testing devices, design systems, and inventory control systems);

(6) machine and process control strategies;

(7) automated sensing for machine and process control and product testing;

(8) practices and activities to implement improved manufacturing methods; and

(9) such other research as the Secretary determines to be consistent with the purposes of this Act.

(b) GRANTS.—(1) The Secretary, through the Office, may make grants to provide for research to increase the amount of fundamental scientific and technological knowledge in fields relevant to manufacturing methods and processes. Such grants shall be made on a competitive basis to applicants who comply with such criteria as are specified in this Act and as the Secretary shall establish, consistent with the purposes of this Act.

(2) A recipient of such a grant may be affiliated with a nonprofit research institution, a private industry or industry association, a university or college, a Center established pursuant to subsection (c) of this section, or any other organization which the Secretary considers appropriate. Any such recipient shall not be required to provide any part of the costs

of such research, unless the recipient desires to expand the scope of the research to be conducted. In such case, the Secretary may enter into an agreement which provides for cost sharing by the recipient.

(3) There are authorized to be appropriated for the purposes of this subsection not to exceed $10,000,000 for the fiscal year ending September 30, 1984, not to exceed $20,000,000 for the fiscal year ending September 30, 1985, and not to exceed $30,000,000 for each of the fiscal years ending September 30, 1986, September 30, 1987, and September 30, 1988. Such funds shall remain available until expended.

(c) COOPERATIVE AGREEMENTS.—(1) The Secretary, through the Office, may enter into cooperative agreements for the purpose of establishing and supporting Centers for Manufacturing Research and Technology Utilization. Such Centers shall conduct research of a more applied nature than the research conducted under subsection (b) of this section. Centers shall study methods of increasing the utilization by the Nation's industries of those modern manufacturing methods which may result in lower production costs and improved product quality and reliability. Such research may be directed toward problems or processes and methods appropriate to a specific industrial sector, including aerospace, microelectronics, mechanical assembly, basic materials, new materials, and transportation.

(2) The Secretary shall enter into any such agreements with consortia of research organizations and manufacturing industries or industry associations. Such agreements shall be made with applicants who comply with such criteria as are specified in this Act and as the Secretary shall establish, consistent with the purposes of this Act.

(3)(A) In addition to funds received under this subsection, a Center may receive funds from Federal agencies and from public and private organizations. Consortia which enter into such an agreement shall provide support and participation in a dollar amount at least equal to the amount of the Federal contribution to be made under this subsection.

(B) For purposes of this paragraph, the term "support and participation" includes cash or equipment contributions in an amount equal to at least 50 per centum of the Federal Government's share, industry personnel to conduct research, and access by persons in the research organizations to modern manufacturing equipment in the participating industry for research and other appropriate purposes. Contributions from nonprofit participants may consist of in-kind contributions. Federal contributions made under this subsection may be utilized only to support expenditures by nonprofit research organizations participating in the relevant consortia.

(4) In entering into such agreements, the Secretary shall consider—

(A) the quality of the research which is to be undertaken as a result of the particular agreement;

(B) the extent of participation by industry in the research to be undertaken as a result of the agreement;

(C) the size of the industrial sector involved and the potential impacts on the productivity of that industrial sector as a result of successful research undertaken through the agreement, as well as the subsequent development and utilization of the manufacturing methods and processes to be studied as part of such research; and

(D) the extent to which entering into the agreement would be likely to increase the number of scientific and technical personnel capable of utilizing modern manufacturing methods and processes.

In addition, the Secretary shall insure diversity among the industrial sectors which are the subject of the research conducted under any such agreement, as well as geographic dispersion of the Centers established and supported under this subsection.

(5) There are authorized to be appropriated for the purposes of this subsection not to exceed $5,000,000 for the fiscal year ending September 30, 1984, not to exceed

$15,000,000 for the fiscal year ending September 30, 1985, and not to exceed $25,000,000 for each of the fiscal years ending September 30, 1986, September 30, 1987, and September 30, 1988. Such funds shall remain available until expended.

ADVANCED MANUFACTURING METHODS RESEARCH UTILIZATION PROGRAM

SEC. 6. (a) ACTIVITIES.—The Secretary shall establish a program of experimental activities, and shall evaluate existing activities, to identify the most feasible means of enhancing the utilization of technologically advanced manufacturing methods by retraining workers who have been displaced from declining industries. The Secretary shall provide for the development, conduct, and evaluation of such experimental activities. The Secretary may, to the extent provided in advance in appropriation Acts, contract with any appropriate person or organization (including States and Centers established under section 5(c) of this Act) to carry out such experimental activities.

(b) REPORT.—Not later than one year after the conclusion of the program carried out under this section, the Secretary shall submit to the Congress a report on such program.

(c) AUTHORIZATION.—There are authorized to be appropriated for the purposes of this section not to exceed $4,000,000 for the fiscal year ending September 30, 1984, and not to exceed $10,000,000 for the fiscal year ending September 30, 1985. Such funds shall remain available until expended.

COMPETITIVENESS STUDIES

SEC. 7. (a) STUDY.—The Secretary shall select specific domestic technology-sensitive industrial sectors and shall analyze such sectors' long-term capability for remaining competitive, especially with industries in foreign countries. In making such selection, the Secretary shall consider industrial sectors which are or are likely to be vulnerable to foreign competition, as well as sectors which are likely to experience rapid and significant growth.

(b) SUBJECTS OF STUDY.—As part of such study, the Secretary shall consider—

(1) the adequacy of technologies utilized to produce the goods and services of such sectors;

(2) superior foreign technologies or unique resources which yield a competitive advantage to industries in foreign countries over similiar domestic industries;

(3) the anticipated scientific and technical personnel requirements for such sectors;

(4) the adequacy of Federal laws and requlations, and the enforcement of such laws and regulations, in

promoting technological innovativeness and commercial competitiveness by such sectors; and

(5) whether changes in such laws and regulations, or the enforcement of such laws and regulations, are desirable to promote technological innovation and competition in such sectors and to safeguard the well-being of the Nation and the public

(c) AUTHORIZATION.—There are authorized to be appropriated for the purposes of this section not to exceed $1,000,000 for the fiscal year ending September 30, 1984, and not to exceed $2,000,000 for each of the fiscal years ending September 30, 1985, September 30, 1986, September 30, 1987, and September 30, 1988. Such funds shall remain available until expended.

ADVISORY COMMITTEE

SEC. 8. (a) ESTABLISHMENT.—The Secretary shall establish a Manufacturing Sciences and Technology Enhancement Advisory Committee to advise the Secretary concerning the activities to be conducted under this Act. The Advisory Committee shall have representation from technology-sensitive industrial sectors, from labor, from the manufacturing research community, and from other sectors which the Secretary considers appropriate. Such members shall be appointed by the Secretary for a term of two years, and shall receive no compensation. Any such member shall, in accordance with section 5703 of title 5, United States Code, be entitled to reimbursement for travel or transportation expenses incurred in the performance of responsibilities as a member of the Advisory Committee.

(b) FUNCTIONS.—The Advisory Committee shall—

(1) review the policies and selection criteria for grants made and cooperative agreements entered into under this Act;

(2) review the progress of the Secretary of Commerce in meeting all the requirements of this Act;

(3) assess the effectiveness of the activities funded pursuant to this Act; and

(4) submit to the Secretary, at least annually, evaluations and recommendations regarding activities carried out under this Act.

(c) REPORT.—The Advisory Committee shall submit to the Congress an annual report on its activities under this Act.

(d) APPLICABILITY.—The Advisory Committee shall be subject to the Federal Advisory Committee Act (5 U.S.C. App. 1 et seq.).

Senator GORTON. The first panel, who may come forward now, consists of Dr. Jack Nyman of Washington State University, Dr. Nancy Jacob of the University of Washington, and Dr. Doug Olesen of Battelle Northwest.

Dr. Nyman, you may proceed.

STATEMENT OF DR. JACK NYMAN, DEAN OF THE GRADUATE SCHOOLS AND ASSOCIATE PROVOST FOR RESEARCH, WASHINGTON STATE UNIVERSITY

Dr. NYMAN. Mr. Chairman, my name is Jack Nyman and I serve as associate provost for research and dean of the graduate school of Washington State University. I wish to thank the Subcommittee of Science, Technology, and Space and its chair, the Honorable Senator Slade Gordon, for the opportunity to provide this statement concerning S. 1286.

As a representative of Washington State University, I find many statements made in previous testimony on the importance and significance of this bill which I might echo. However, earlier testimony also presented some points of view with which I differ.

In the letter of invitation to attend this hearing, three areas were identified as being appropriate for discussion. The second area regarding universities' priorities for manufacturing engineering is an item on which I would like first to comment. Priorities for research programs and new education programs are tied very closely to the ability to obtain funds for them. It is a known fact that manufacturing engineering research and education are high cost areas among our engineering and science disciplines. Mr. Ernest Finn, vice president of the Boeing Commercial Airplane Co., made that very clear during his earlier testimony regarding this bill. In this testimony, he pointed out that to do research and provide education in these state-of-the-art areas does require considerable investment for improvement of laboratories and strengthening of faculties. These conditions in our universities today are the result of past decisions to forego these high cost research areas in favor of more affordable and more readily fundable programs of national concern. This was true in the 1950's and 1960's when our universities were helping our country improve its space technology and contributing to the marvelous and astonishing accomplishments of that program.

During the 1970's, reduced funding levels did not allow universities to provide the resources for both computer and manufacturing engineering. Most chose to put what limited resources were available into computer science and computer engineering. As we have moved into the present decade, it has been very difficult to initiate or improve programs in manufacturing engineering research and education because of the continued severe funding problems in both public and private institutions. During this difficult economic period, many university professors wished to expand research and educational efforts in manufacturing engineering, but were frustrated in doing so because of these severe funding limitations. Now that the economy is improving, there is an expectation on the part of many that programs in manufacturing engineering will be initiated. Such research and education programs require participation of faculty for all engineering and scientific disciplines. Provision of proper laboratories and support as provided in S. 1286 will encourage talented people on our faculties to contribute, as they did during the 1960's, toward solving our manufacturing problems. The enthusiasm and participation of faculty in any endeavor are determined largely by the interest shown and support provided by the university, State government, Federal Government, and industry.

S. 1286 expresses a concern, with which we agree, that there needs to be an increase in the number of scientific and technical personnel capable of utilizing modern manufacturing methods and processes. During an earlier hearing, Dr. Daniel Berg provided testimony on behalf of the Association of American Universities. In that testimony, he stated that geographical dispersion of centers for manufacturing research and technology created by this act should not be a primary issue. It is my considered opinion, however, that a distribution of centers and funding of research grants under this bill should take geographic factors into consideration to assure that all areas of the country benefit appropriately and are provided with the trained professionals and sources of technological research which are needed to sustain economic bases in the communities.

Finally, I believe the university research community, in consort with industry, can, during this decade, become a major source of scientific and technological innovation in manufacturing. I sense no reluctance on the part of my colleagues to become involved in this type of research or to establishing closer working relationships with industry, but rather that they are looking for the encouragement and support that S. 1286 provides. They know that the new high tech areas need their skills for manufacturing engineering research and improving manufacturing education. They know that machine tools, robots, computerized manufacturing systems and manufacturing system control are areas with challenging problems to be solved. These problems involve sophisticated concepts in control algorithms, unique applications of thermodynamics, fluid mechanics, dynamics, vibration theory, and many other areas of science and engineering. I am confident that the fabric of success for this effort will depend upon the mixing of all of these technical skills through increased involvement by many universities and industries in this country. S. 1286 would help promote this involvement.

Thank you for this opportunity to present my views.

Senator GORTON. Thank you very much, Dr. Nyman. Dr. Jacob.

STATEMENT OF DR. NANCY JACOB, DEAN, SCHOOL OF BUSINESS ADMINISTRATION, UNIVERSITY OF WASHINGTON

Dr. JACOB. Thank you. I hope this microphone works. My name is Nancy Jacob, I am dean of the school and graduate school of business administration at the University of Washington. I'm delighted to be here today to testify with such a distinguished panel on the subject of S. 1286. It goes without saying, perhaps, that a lot of press coverage has been generated recently concerning the facts that Senator Gorton introduced in his preamble to this hearing. Those facts demonstrate that a number of more or less traditionally strong industries, from chemicals to plastics, drugs and steel and automobiles, are affected. The press over the years has cited a variety of reasons for the problem, from the Federal Government's lack of encouragement for private savings and investment to the shortsightedness of American business managers. The fact is that America is losing its competitive advantages in some industries across the world. Regardless of who or what is technically to blame, certain facts do stand out.

First, recent studies, including one produced by the Committee for Economic Development, suggests that the problem is not one of inadequate expenditures on private nonmilitary research, at least in gross terms. On a per capita basis, we do know we do about as well on this score as do our Japanese and West German competitors. Where we seem to fall down is in the nature of research that is conducted. Perhaps we are spending more money making marginal improvements in production processes and less on developing more major breakthroughs, and also in translating the results of research into capital investment, in certain industries.

Now, it seems that there are two perfectly proper roles for Government to play in encouraging solutions to this problem. The first is really the essence of S. 1286, that is, to subsidize research which will produce more efficient manufacturing technologies, and encourage the transfer of these technologies into industrial processes. This needs to be done for two reasons: Private industry, left alone to cope with the enormity of the potential research agenda, faces economies of scale, especially in basic research, which essentially mandates cooperative undertakings with Government, academe and other business firms.

Second, there are positive externalities to society which cannot be fully captured from the firm conducting the research. By subsidizing research and by encouraging joint industry-Government-academic funding of that research, the Government can actively help solve the problem. Some of the barriers that have existed in the past for cooperation are related to the lack of funding for research, particularly in the academic sector, but also to a lack of dialogue on occasion between industry and academe. I think this bill would help both problems.

The second thing Government can do is to provide incentives to firms and to labor to deal with the short-term costs of technological change on organizations. If I were a business manager who could greatly reduce production costs and improve product quality by introducing robots on a plant floor, but doing so would eliminate 100 jobs, I should expect to get some help from Government in dealing with the social costs of that change.

Clearly these social costs cannot be borne entirely by labor, nor can industry be expected to fund them all. That is, if we want this kind of technological change to happen. The current bill, S. 1286, makes a welcome effort to begin addressing these problems, and that's a very good sign.

What Government should not do, in my opinion, is to respond to the problem by erecting trade barriers, subsidizing declining industries, or by enacting a massive regulatory program or nationalized industrial planning. These approaches do not work, because history tells us that innovation is borne out of a pluralistic, decentralized and individualistic approach to problem solving. It does not flourish in a centralized group think approach to that problem solving.

I do worry about a few minor points in this bill as it is currently written. One is the magnitude of the dollars to be allocated to fund its programs, especially with the stipulation that these dollars be spread out across industries and geographically. I also worry a little bit about the lack of specificity concerning the rights and obligations of the grant and cooperative arrangement participants to release publicly the research results.

Finally, I think it is possible to overemphasize the technological aspects of industrial competitiveness. There are a great many organizational aspects related to the effect of technological change or productivity. These need to be addressed, too, because all individuals in a manufacturing enterprise need to develop an appreciation of the role that motivation, worker involvement and job design play in productivity. This bill does not address those issues. Nonetheless, it is a very worthy start toward a solution of the problem at hand.

I am very supportive of the concept of S. 1286, and I'd like to add that I think one aspect that is often overlooked is the bill's lack of specificity with respect to which industries would be subsidized and which technologies will be left aside. I think that's very encouraging, because we don't always know which technologies are the ones that will flourish in the 1980's and the 1990's. Thank you very much for this opportunity.

[The statement follows:]

STATEMENT OF DR. NANCY L. JACOB, DEAN, SCHOOL OF BUSINESS ADMINISTRATION, UNIVERSITY OF WASHINGTON

Mr. Chairman and members of the Subcommittee on Science, Technology and Space of the United States Senate, my name is Nancy L. Jacob. I am Dean of the School and Graduate School of Business Administration at the University of Washington and also Professor of Finance and Business Economics at that institution. This is my first appearance before you, and I am delighted to be given the opportunity to express my views concerning Senate Bill 1286, the "Manufacturing Sciences and Technology Research and Development Act of 1983."

There is no longer doubt that the United States has lost much of its mid-20th century dominance in world trade. The American public is being deluged with books and articles attempting to assess the damage, to pinpoint the root causes and to propose solutions. From Business Week, the New York Times, the Harvard Business Review, and even the scholarly community, we have learned the striking economic news: We now know, for example, that the Japanese can build and ship a passenger care to the U.S. west coast for up to $1,500 less than it costs Detroit to do the same thing. We also know that the U.S. percentage of total world trade dropped from over 25 percent of exports in 1960 to about 17 percent in 1977; a figure that is still slipping today.[1] While in 1960, about 95 percent of the world's radios and television sets were U.S.-made, today virtually all radios are made by the Japanese, as are most television sets and home video recording units. Even industries in which we have traditionally been virtually, invulnerable have lost market share dramatically since the 1960s, from plastics and chemicals to steel and drugs. Though historically, the U.S. has been responsible for many of the world's major commercially successful innovations—from airplanes and transistors to televisions and computers—we have slipped dramatically in our ability to compete in the production of goods incorporating these innovations. Now a matter of almost overriding national preoccupation, this crisis obviously has profound implications for governmental policymakers.

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[1] Source: "Overview of Current Status of U.W. Manufacturing: History, Status, Impact on U.S. Economy, Forces at Work, Education," James Brian Quinn, November 4, 1982. Keynote Speech, Technical Session, National Academy of Engineering.

Unfortunately, awareness of the gravity of the problem is easier than determination of its root causes. Some writers, including Robert Reich, have pointed to U.S. industry's oligopolistic structure and the lack of incentive it provides for innovation, encouraging insteaa a sort of "paper entrepreneurialism," or rearrangement of assets to maintain profits, as well as the advocation of government subsidies and the erection of trade barriers against imports. Still others blame the Federal government for discouraging personal savings and dampening potential productivity-improving capital investment. These critics correctly observe that the Japanese, the French, the West Germans, the British, and the Canadians all save a percentage of personal disposable income which is more than twice as great as our own, and that that reasons for this can be found in the Social Security system, the federal personal income tax code, and Regulation Q (now being phased out). Others point to business managers as the culprits, observing that U.S. business managers are shortsighted, unwilling to take risks, noninnovative, and overly analytical. As a result, they have shunned investment in new technologies and diverted R&D expenses away from basic research and toward short-term objectives, such as how to improve the taste of your breakfast cereal or remove the spots on glassware left by your dishwasher detergent. These same critics add that U.S. business schools are largely responsible for this state of affairs; since, in the words of Business Week, "large corporations have been virtually overrun by a proliferation of profit-zealous MBA's who are turning every nut another half turn to get a payoff."

If the problem of American competitiveness in world markets is ever to be solved, we have to turn off this rhetoric about who is to blame and why. We must instead concentrate on what we are after, and how the roles government, labor, business, and consumers lay interact with possible solutions. As a starting point, most of us could agree that what we seek is enhancement of our standard of living. Within that, we know that our standard of living rises in real terms only as the personal incomes of workers rise. And incomes rise only as the productivity of labor increases.

When we frame the solution in terms of productivity, various pieces of the puzzle fit together. The single most important influence on the productivity of labor over the past 200 years or more has been technological change. Scientists tell us that technological advancement has accounted for as much as 80 percent of the increase in our standard of living during that time. The implementation of this change is preceded by three things: (a) management's perception that innovation is needed and can be profitable, (b) the decision to engage in R&D, and (C) the implementation of innovation through capital investment.

In this regard, the Committee for Economic Development in a recently issued report on productivity, found that the problem does not seem to lie primarily with (b), the decision to engage in R&D. The CED found that U.S. outlays for nonmilitary research have actually risen in absolute terms and in relation to GNP in recent years. Our R&D expenditures—on a per capita basis—compare favorably to those of the Japanese, West Germans and other industrial competitors. The problem, rather, seems to lie with (a) and (c); that is, with management's perceptions of the necessity and profitability of innovation, and with the follow up from research to production. (A striking example of (a)—though there are many others—is IBM's early refusal, after seeing the first prototype of an Apple computer, to accept Steven Jobs' offer to produce and market it for the consumer market.) The government has an important role to play in these two areas for one significant reason: Technological innovation and technology transfer have highly uncertain payoffs for any single firm. Though the risks to be an individual firm are great, for society they are less so, because new technologies can readily be transferred among firms and across industry boundaries. Historically, about half of the benefit of technological innovations in the manufacturing sector has accrued directly to the service sector. And, in 1980, services accounted for a $5.8 billion positive balance of trade in the U.S. The most obvious example of innovations of this type are the introduction of the computer and recent improvements in telecommunications made possible by the laser, but there are many others, as well.

The point is that manufacturing executives have incomplete incentives to invest in a level of R&D which is adequate from society's standpoint, simply because their firms face highly uncertain payoffs and are unable frequently to capture all those payoffs. Thus, some desirable research is not conducted at all because it fails to meet the profitability standard firms quite appropriately employ. Scientists in the private sector—as in the public sector—always work for managers who are responsible for the "bottom line." And it is the "bottom line" which inevitably determines which research gets done and which does not. What I am saying is that it should be "society's bottom line," just as much as "General Motors' bottom line" which influences the size and composition of our outlays for research, particularly basic research, if we are to protect our future standard of living.

How do we factor in society's objectives? Assuming we know what they are, there are two ways. The first is to subsidize both basic and applied research. I do not think it possible to subsidize just basic research, or just applied research, and have a successful result. The long-term perspective on these things requires that we look not only at what is likely to pay off 20 years from now, but what we can bring into immediate use. Applied research also has payoffs for basic research, and vice-versa, and many of the academic and nonprofit institution involved in one type of research are also intimately involved in the other. This subsidization of research can be accomplished through legislation such as S. 1286. I particularly like this aspect of the bill, because it makes clear the federal commitment to both types of research and encourages and reinforces the collaborative roles that government, industry and academic organizations play. It also makes clear that government cannot do it alone; that industry, especially, is needed as an active participant, particularly in the establishment of Manufacturing Research and Technology Utilization Centers. I also favor the relatively permissive language about what types of research might be supported under the act, because the federal government is unlikely to be as prescient about future technologies and they myriad of would-be entrepreneurs and capitalists who populate this country and think independently and creatively about the future and who are not burdened by having an official stake in the outcome. It is generally dangerous for the government to enact legislation distorting the flow of capital to, or away from, certain technologies or industries relative to others. This bill flirts closely with that temptation but wisely stops short of succumbing, although the result may depend on how the Commerce Department interprets the language in Sections 5 (a) and (c) which enumerates the types of research and the types of industries targeted under this Act.

I worry that the bill provides so little potential funding for research grants and cooperative agreements and for such a short period of time, that it may not have the intended effect. And, the requirement that the support provided be spread out geographically and across industries may further dilute the effect of such as small funding base. If these factors deleteriously affect the Act's effectiveness as assessed by the Manufactuing Sciences and Technology Enhancement Advisory Committee, will funding be reduced or eliminated? The citizens of the nation frankly need a long-term commitment from the government, not a short-term fix. I hope that if S. 1286 is enacted, that it be supported fully for a considerable period of time before its effectiveness is assessed fully.

A second thing the government can do is to influence the economic incentives of business firms, industry, labor, and consumers. Business firms and labor unions should not be left alone to deal with the consequences of social change wrought by technology, since these are externalities to the capital investment decisions businesses make. And firms will not invest in flexible-system production, for example, if the resulting problems with labor unions are seen drastically to influence production costs. The government must not only "push" firms toward research but it must "pull" them toward implementing innovation by lowering the perceived costs of that implementation especially where externalities—such as social pressures to maintain existing jobs and wage rates—impinge on capital investment. Of course, it can also accomplish much by directly improving the financial incentives for capital investment investment through tax code revisions, but this approach alone cannot overcome the barriers imposed by worker resistance to technological change. S. 1286 makes a very welcome start by providing funds to experiment with methods of retraining workers who have been displaced from declining industries. However, the bill might be made more effective if it were more broadly focussed on methods of enhancing vocational training in general, rather than on retraining displaced workers. I can envision a whole bureaucracy set up just to determine who qualifies under this legislation as a "displaced worker" and which industries are certified as "declining." Beside the fact that there will be many workers, including bank tellers and parking garage attendants, who are displace by technology in nondeclining industries, this language overlooks a major question lurking behind all this. It is: How can our educational system more effectively deliver the kinds of vocational training needed to support rapid technological change?

This is an area where I believe our educational system has begun to fail, and where it desperately needs help. We need vocational schools, of the sort that exist in Europe and Australia, and the kinds of on-the-job training programs that manufacturing firms in Japan employ so heavily. Our universities are not equipped to provide vocational training, and what capacity or community college system has for this purpose is currently clogged with an orientation toward personal fulfillment and self-help courses. There is simply not enough industry participation in specific vocational courses of study at such institutions, especially in computer training and manufacturing skills.

Many of the individuals who have testified before you have also pointed to the need for additional manufacturing engineering programs in universities. These, too, are important. The University of Washington is in the process of developing such a program and, at the same time, enhancing its Industrial Engineering Program. The cornerstone of these efforts is the newly established John Fluke Chair in Manufacturing Engineering. The faculty involved in this program are developing cooperative links with the business school so that students will have the ability to study both managerial and technical aspects of manufacturing processes and quality control. That balanced emphasis is crucial to success. Without managers who understand the human side of technological change and can gain worker enthusiasm for productivity improvements and improved product quality, there can be no effective national program for encouraging technology transfer. Like scientists, engineers also work for managers who must be convinced of the benefits of technology.

Historically, you might be interested to know that the study of production and operations management in graduate schools of business throughout the country has been rather "out of vogue" for about a decade, and it is only now regaining considerable student interest. During the past few years, more than two-thirds of the MBA students at the University of Washington, as well as at most major graduate schools of business, have chosen instead to concentrate their studies either in finance, accounting, or marketing. Technology simply isn't the whole answer to our problems; the perceptions of future managers about technology is a large part of it, too. In this regard, S. 1286 may emphasize techology too much, without recognizing the importance of training effective manufacturing managers. For example, I'd like to see additional consideration given to the encouragement of engineering and science students to pursue complementary studies in management.

I'd like to add that I see only one significant barrier to industry-university collaboration in research. And that is that increasingly universities have less and less to bring to the table. As members of this committee well know, University equipment is, in many cases, outmoded and our low salaries have resulted in many scientists leaving academe altogether. How can we collaborate with industry when industry is already ahead of us?

Thank you for this opportunity to appear before the Subcommittee to present my views on this important bill. In spite of my criticisms of specific portions of the S. 1286, I am indeed in favor of its passage. It begins what can be a very constructive process of joint problem solving between business, industry, and academe.

Senator GORTON. Thank you, Dr. Jacob. The formal written statement which you submitted in connection with this hearing will also be included in the record. Dr. Olesen.

STATEMENT OF DR. DOUG OLESEN, DIRECTOR, BATTELLE NORTHWEST

Dr. OLESEN. Thank you, Senator Gorton. My name is Doug Olesen, I'm vice president of Battelle Memorial Institute and director of its Pacific Northwest Division. It's a pleasure for me to be here today to discuss manufacturing technology and some of the problems and possibilities I see in relation to S. 1286. My perspective is based on the experience of an organization which has been meeting the research and development needs of both Government and industry for 50 years.

If we have fallen behind foreign competition in manufacturing technology, it is not for the lack of intelligence or creativity in this country. We have in part been hampered by a lack of properly trained individuals, need for more incentives to invest in the right kind of research, and the lack of a formalized mechanism for unifying the efforts of industry and Government to reach common goals.

Foremost, if we are to advance manufacturing technology, we must equip more people with a broad base of experience. Single-discipline researchers who focus on individual projects and narrow applications of new knowledge are important, but knowledge and experience that expand the boundaries of academic disciplines are essential to making marked improvements in manufacturing technology.

The practical demands of these tasks require the united talent of individual contributors capable of performing in a teamed approach to product and process problem solving. We know the difficulty of finding people with that kind of experience in attempting to recruit staff for our own manufacturing research programs.

The problem, I think, is that current research and development efforts are primarily proprietary-industrial R&D or highly focused Government projects. Both cases have built-in demands for already qualified staff, and almost no tolerance as a mechanism to increase the pool of experienced contributors. Features of this bill offer to improve that situation by providing an appropriate vehicle for expanding the base of applied experience.

At the present time, the Nation's existing research organizations represent the principal resources of divergent skills which are teamed together to produce practical answers and solutions relating to new products and processes for industry. S. 1286 offers an opportunity to increase this cadre of qualified personnel through public sector support of applied research programs. Your proposal to establish centers for manufacturing research and technology utilization is a welcome and comfortable concept for many of us. Organizations such as Battelle are managing active programs in applied research and the transfer of technology to the marketplace. Mechanisms for the management of both Government and industry funded programs in the same organization are well established. Investigations that produce group-shared results while protecting the interests of individual participants are in place. I invite your attention to increased use of these existing research and development resources as the basis for the proposed centers.

I have one major point of recommendation for the committee. That is the reconsideration of the use of grants as the primary vehicle for stimulating innovations in manufacturing technology. Grants with no fee or other remunerative incentive may limit the interest of qualified organizations and the kinds of resources that will be committed to this important effort. On the other hand, the directed efforts of qualified talent on specified tasks—the basis of contract awards—offers to attract more organizations and increase the level of commitment toward your aims.

Advancing our capabilities in manufacturing technology is fundamentally the responsibility of industry. Government can facilitate that advancement by supporting research and development that focuses on technologies which are relevant to industrial needs.

S. 1286 provides a necessary structure for defining these priorities in a collaborative setting. It provides a vehicle for building a new Government partnership with industry. An important first step. Thank you.

Senator GORTON. Thank you very much, Dr. Olesen.

[The statement follows:]

STATEMENT OF DR. DOUGLAS E. OLESEN, VICE PRESIDENT AND DIRECTOR, PACIFIC NORTHWEST DIVISION, BATTELLE MEMORIAL INSTITUTE

Senator Gorton and members of the committee.

It is a pleasure for me to be here today to discuss manufacturing technology and some of the problems and possibilities that I see in relation to Senate Bill 1286.

My perspective is based on the experience of an organization which has been meeting the research and development needs of both government and industry for 50 years.

If we have fallen behind foreign competition in manufacturing technology, it is not for the lack of intelligence or creativity in America. We have been hampered, instead, by lack of properly trained personnel, the need for more incentives to invest in research costs, and the lack of formalized mechanisms for unifying the efforts of industry and the government to reach common goals.

Foremost, if we are to advance manufacturing technology, we must equip more people with a broadbase of experience. The single-discipline researchers who focus on individual projects or narrow applications of new knowledge are still needed. But knowledge and experience that spans the boundaries of academic disciplines are essential to making marked improvements in manufacturing technology.

The practice demand of these tasks require the united talent of individual contributors capable of performing in a teamed approach to product and process problem-solving. We know the difficulty of finding people with that kind of experience in attempting to recruit staff for our own manufacturing research programs.

The problem, I think, is that current research and development efforts are either proprietary-industrial R&D or highly focused government projects. Both cases have built-in demands for previously qualified people, and almost no way to increase the pool of experienced contributors. Features of this Bill offer to improve that situation by providing an appropriate vehicle for expanding the base of applied experience.

At the present time the nation's existing research organizations represent the principal resources of divergent skills which are teamed together to produce practical answers and solutions related to new products and processes for industry. Senate Bill 1286 offers an opportunity to increase this cadre of qualified personnel through public sector support of applied research programs.

Your proposal to establish Centers for Manufacturing Research and Technology Utilization is a welcome, and comfortable, concept for many of us. Organizations such as Battelle are managing active programs in applied research and the transfer of technology to the marketplace. Mechanisms for the management of both government and industry-funded programs in the same organization are well established. Investigations that produce group-shared results while protecting the interests of individual participants are in place. I invite your attention to increased use of these existing research and development resources—as the basis for the proposed Centers for Manufacturing Research and Technology Utilization.

I have one major point of recommendation for the committee. That is the re-consideration of the use of grants as the primary vehicle for stimulating innovations in manufacturing technology. Grants with no fee or other remunerative incentive may limit the interest of qualified organizations and the kinds of resources that will be committed to this important effort. On the other hand, the directed efforts of qualified talent on specified tasks—the basis of contract awards—offers to attract more organizations and increase the level of commitment toward your aims.

That our national efforts fall short of meeting the country's real needs in manufacturing technology can be attributed to the low funding priority assigned to applied scientific research and engineering development. While other industrial nations have been increasing their support for the past decades, our investment, in constant dollars, has not kept pace with real needs. Senate Bill 1286 is a step toward a practical remedy.

Advancing our capabilities in manufacturing technology is fundamentally the responsibility of industry. Government can facilitate that advancement by supporting research and development that focuses on technologies which are relevant to industrial needs.

Senate Bill 1286 provides a necessary structure for defining these priorities in a collaborative setting. It provides a vehicle for building a new government partnership with industry. It is an important first step.

Thank you.

Senator GORTON. Dr. Jacob, in your written testimony you commented on the study of production and operations management in graduate schools of business, and you observed that it has been out of vogue for about a decade. You also pointed out that it now appears to be regaining student interest. To what do you attribute that renewal of interest?

Dr. **Jacob**. I think there's a national concern now with technology and business management, particularly in comparing us with the Japanese, and I think that in itself has created a lot of student interest.

Senator **Gorton**. Do you think it's going to have any long range effect?

Dr. **Jacob**. I think if there's a sustained emphasis nationally to revive and move ahead with our manufacturing sectors, that yes, that will happen. I think a lot of student interest, too, has been dictated by what students perceive as being the job market and potential salaries, and salaries on production-related jobs have not been as high as they have been in finance and accounting. That may change, as well.

Senator **Gorton**. It's changes like that, I think and those that we can promote through this kind of activity, that are going to result in benefits.

Dr. **Jacob**. I would hope that there would be some effect.

Senator **Gorton**. Dr. Nyman, I know that you've been active in the area of State initiatives in high technology, and that one activity in which you're involved is the High Technology Coordinating Committee. I understand that one focus of that committee is technology degrees as opposed to engineering degrees. Could you comment on that, and how that's likely to affect the area of manufacturing technology and the university community?

Dr. **Nyman**. There are two schools of thought with that issue, the bachelor of technology programs are 4-year programs to train people for specific jobs and specific industries. Even among the industrial community and the groups that are represented on the Governor's High Tech Committee, there's a division of thought. One group feels that training at this level leading to the bachelor of technology degree is just exactly what is needed to help industries in their present requirement, to get them started, to help them progress, to provide them with the cadre of trained people that they need. There is another group, however, and including some engineering organizations, who feel that training at the bachelor of technology level leads to dead end positions, and that students would be better advised, if they want to become technologists, to take a 2-year degree and then depend on training within the industrial organizations. Then, of course, if students want a 4-year degree they should take a bachelor of science in engineering, which then prepares them for a lifelong career, hopefully, that they will be educated to the point where they can continue to educate themselves and participate in continuing education courses to be able to shift jobs as new industries come into vogue and old ones phase out.

Senator **Gorton**. Do you think there's a major untapped area in this entire field for continuing education, after degrees, proceeding on a part-time basis?

Dr. **Nyman**. Very much so. And this is being pursued very vigorously by the State of Washington, in that a statewide telecommunications network has been authorized by the legislature, and

Washington State University and University of Washington jointly are moving forward rather rapidly to get programs into place so that we can offer masters programs next fall through this telecommunications network.

Senator GORTON. Dr. Olesen, I'm told that you're serving not only on the board of the Washington Technology Center, but also on the Washington Council for Technology Advancement. In your view, what are the relative responsibilities of industry groups, universities, the Federal Government, and State and local governments, in a successful overall research effort?

Dr. OLESEN. Well, in the case of manufacturing technology, I think a great deal of the responsibility or the burden must fall on industry. I see manufacturing technology as highly applied and highly specific to particular industrial sectors, so I think industry must be in a leadership position if the technology is going to be ultimately utilized in any kind of a near-term timeframe.

I see the university community as very supportive of that, and directly involved. In one case, in actual training in the academic disciplines, providing the trained staff that will go into industry to make those things work, on one hand; and on the other hand, providing actual research vehicles which industry can utilize, and thereby not having to have a full complement of research capability internal to the industrial organization.

I think both the State and Federal Government responsibilities in these areas are really supportive in terms of legislation, tax incentives. Ability for industries to work together in groups without antitrust difficulties I think are important. Providing the supportive atmosphere and the right kind of legislation. Sponsoring basic research is another element which Government can provide support, and I think your bill in particular fits that role very well, as far as the Federal Government is involved.

Senator GORTON. As you know, S. 1286 provides for centers for manufacturing research and technology utilization. How can they complement or support, or will they conflict with the existing and proposed efforts, especially those that have been taken here in Washington State?

Dr. OLESEN. No, I think it's directly complementary. I think the basis or the framework for these centers already exists, and I think the bill provides a mechanism to get funding to those centers. The Washington Technology Center, in particular, is an obvious vehicle that could become a center, and already is set up, to bring industry together to work on high technology problems. One of its shortcomings, of course, is being able to get the right kind of funding. I think this bill is directly relevant to that center.

Senator GORTON. In your written testimony you make one major point of recommendation to the committee, and that is the reconsideration of the use of grants as opposed to directed efforts of qualified talent on the basis of contract award. Would you expand on that idea? What was the rationale, and how you would change this legislation?

Dr. OLESEN. I think that organizations that have an investment in facilities, people, equipment, that are applying that to the research mode have an opportunity to go after grants and have an opportunity to apply those resources under contract with a fee.

And my point here is that limiting it to grants will limit the fraction of those resources that will be applied in this direction. If it's under contract, there's an opportunity for fee and some return on the resources applied in this direction, and I think that a larger cross section of industry and research community will be interested in and participate in this bill.

Senator **Gorton**. I would appreciate it if you would write to us after this hearing is over with the specific change on the statutory language you would recommend in that avenue.

Dr. **Olesen**. I will.

Senator **Gorton**. The university research community has been a major source of scientific and technological innovations in many fields. But the universities have given manufacturing engineering a low priority. And each of you have offered some insights into why that's so. Additionally, as you know, there are only a very small number of programs in manfacturing technology in our universities. How would you compare the priority given by both our foreign industrial competitors and foreign universities in the manufacturing research and education? Have any or all of you encountered that?

Dr. **Nyman**. I'm afraid I am really not in a position to make a definitive statement. I have an opinion, but it's not founded on very good insight, perhaps I ought to just keep it to myself.

Senator **Gorton**. I'd be happy to have your opinion.

Dr. **Nyman**. Well, I think we could do more than we have, and probably at the present time some countries, Japan particularly, have been more effective in making use of what knowledge is available than we have.

Senator **Gorton**. Dr. Jacob.

Dr. **Jacob**. I, not being an engineer, would stop out on dangerous turf, if I were to comment on that. I can say that it's my impression that the Japanese, for example, emphasize science and applied science related topics at an earlier age in the educational system, and it would not surprise me if that emphasis at an early age didn't translate later on into more applied work in this kind of area.

Senator **Gorton**. Dr. Olesen, do you have a view on that subject.

Dr. **Olesen**. I'm afraid I'm not directly knowledgeable in that area, although I guess I have some opinions in that area, also. And I think it has less to do with the actual education programs in the universities as it has to do with the attitude of governments and the way government and industry works together and the way that industry is able to apply traditional academic disciplines that are coming out of the universities.

Senator **Gorton**. Let's change the focus of the question from foreign competition to the competition for attention in educational institutions from other allied fields. How is the vitality of manufacturing research in education compared with other engineering disciplines in the United States, for example, electrical, aeronautical, and mechanical?

Dr. **Nyman**. First, let me answer that, I think it's clear that it has never received as high a priority and probably lags considerably. I think there are some things that could be done which would move things along rather rapidly. One might be the provision of training grants with the stipend sufficiently high to attract people into the graduate programs in engineering. The other would be the provision of equipment and facilities. These areas would require, I think for most of the universities, some additional facilities. And perhaps beyond that, some help in obtaining faculty, because universities are having a very difficult time recruiting faculty because of the differential in salaries between universities and industry. All that might be done, but I don't know that it would solve the problem.

Senator GORTON. Would either of you like to comment on that question?

With that, I should like to thank each of you for your attention to this proposal and your contributions you have made.

Dr. JACOB. Thank you.

Senator GORTON. Our second panel will include Mr. Larry Mayhew of Data I/O and Mr. Hunter Simpson of Physio-Control. Mr. Mayhew, we'll hear from you first.

STATEMENT OF LARRY MAYHEW, PRESIDENT, DATA I/O

Mr. MAYHEW. Chairman Gorton, members of the committee, ladies and gentleman: I thank you for the opportunity to express our views on S. 1286. I'm Larry Mayhew, president and chief executive officer of Data I/O of Redmond, Wash., an electronics manufacturer of equipment used in the design and production of digital electronics products. We employ approximately 500 people and will grow about 50 percent this year. Data I/O sells approximately half of the world volume in dollars of similar equipment. Our primary competition is a much larger German firm and a group of smaller Japanese companies.

Our leadership is strengthened through the close relationships we have built with the large semiconductor manufacturers, both in the United States and in Japan.

I believe that the maturing nature of most markets brings more pressure on manufacturing performance in productivity and quality. And if a large participant retains the best quality and productivity into that phase of the market's development, and as the differentiation between product brands weakens, they will have the right to continue as a large participant. By that time, usually the market has rationalized into positions for each of the major competitors, and normally the factors that destabilize those positions are managerial complacency or technology change. And I'd like to speak about technology first.

The word technology all too often is applied to just new scientific advances, but in fact it should be used for improvements in techniques to performing old functions, as well. The technology of manufacturing is as important to the health of U.S. industry as is any scientific advance, because the real payoff is not in discovery, but in the application, widespread application, and that follows skillful innovative design and development, not only for use, but in production efficiency as well.

In earlier testimony Professor Holland of MIT pointed an accusing finger at the management of American industry, and I find myself largely in agreement with him. I will, however, suggest that managers are like most others, they respond to their environment.

I believe the answer to improved use of modern manufacturing technology lies in the motivation of corporate America's leadership. In February of this year, the Commerce Department published a report assessing the competitiveness of high technology industries in the United States and elsewhere, and it states that, and I quote from that document, "While the United States continues to lead in research and design, Japan has far surpassed it in robot production and use."

Now, I can only speculate on the reason for this, but I suggest that our manufacturing engineering and industrial engineering people nationwide have anticipated or perhaps even received direct resistance from organized labor who believe that jobs are threatened by the applications of manufacturing technology. Certainly, the use of robotics in Japan has strengthened the market position of Japanese companies enough that it has created jobs for Japanese employees.

For several years I was a member of the board of the American Electronics Association, and I was its chairman in 1981. I was responsible for updating the association's objectives in 1982. I currently serve as a member of the AEA's National Competitive Strategy Committee.

The AEA is only one of many bodies worried about our Nation's industrial competitive posture, and most have developed some deep convictions concerning the best role the Government can play to foster an environment that will produce growth in exports, growth in jobs, and eventually growth in tax revenues.

The AEA's position, and one that I support, is really seven points. The first is vigorous open competition, including free international trade. Adequate availability of and access to capital, including risk capital. A climate that fosters innovation and provides commensurate returns for risk-taking entrepreneurs. The availability of qualified people. Opportunity or continuing management education, including means of improving productivity and product quality. A cooperative relationship with Government, free of excessive regulation. And last, a safe and healthful work place for employees and a community environment enhanced by our business presence.

Where possible, I believe governments should follow these priorities. These are the areas where energy is best spent. The legislation proposed by S. 1286 and the funds appropriated may produce the results you're looking for, but I would spend the money to discover why industry doesn't perform on its own. I believe the reasons lie in the tax structure and the incentives to modernize production processes, rather than the availability of technology. Thank you.

Senator GORTON. Thank you. Mr. Simpson.

STATEMENT OF HUNTER SIMPSON, CHIEF EXECUTIVE OFFICER AND PRESIDENT, PHYSIO-CONTROL CORP.

Mr. SIMPSON. Chairman Gorton and members of the committee, I'm W. Hunter Simpson, president of Physio Control and a member of the board of regents of the University of Washington. Physio Control is a division of Eli Lily Co. and has its corporate headquarters also in Redmond, and is a producer of devices and materials for the health care industry.

The committee is to be commended for holding the hearings on S. 1286, the Manufacturing Sciences and Technology Research and Development Act, a bill which I support. This act focuses on a crucial element of the Nation's industrial sector which must be reinvigorated if we are to be successful in maintaining a viable national economy. The post-World War II years have been marked by an inevitable resurgence of the economies of those nations which were subjected to privation or devastation of the war. Resurgence in and of itself is no cause for alarm, but when one observes the collapse or threat of collapse of our heavy industry in the face of international competition, one must question whether it is in the interests of economic survival or national security to ignore that challenge. One also observes that our international competition is mounting strong challenges to our current leading technological intensive industries: commercial aircraft, microelectronics, computers, and those of like complexities.

Recent studies[1] have provided statistical evidence that the Nation's industries are lagging in productivity, that the Nation's industries' share of both internal and external markets are declining, and that our principal economic competitors are more successfully using modern technology and marshaling human resources in this race to capture markets.

While this state of affairs results from a combination of many factors, some of greater importance than others, one especially significant factor is that of research and development in manufacturing technology. The Nation has in the past decade or so lagged behind other nations such as Japan and the Federal Republic of Germany in research and development and, more importantly, in the industrial application of the new technology. If we are to establish a leadership position in manufacturing technology, we must develop both human resources and the technology to revitalize our heavy industries. Such an effort would require the joint cooperation and action of business, government, and academe as proposed in S. 1286.

The committee may ask why, given this state of affairs, there are so few strong programs in manufacturing technology in the universities. The complete answer to that query has many facets; only a few can be touched upon at this time. In the 1940's and the 1950's there were many strong programs in production engineering. In the 1960's these programs atrophied and declined; only a few survived. The survivors and the remnants provide the basis for the stronger efforts in manufacturing engineering.

In part, the decline of the 1960's was a product of the post-Sputnik era. The emphasis of engineering shifted from the efficient manufacture of large numbers of units of product to the design and construction of a small number of products which had high reliability and whose cost was at best a secondary factor. University engineering research in the 1950's was being nudged into engineering sciences by the profession and the space race. Industry support of university research was reduced in some cases because of the emergence of corporate basic research laboratories, and in others because industry failed to recognize the intangible returns from support of university research. The growth and funds for basic research from Government mission agencies also tended to divert university engineering faculty from research opportunities offered by the manufacturing industry. Also in the 1960's the technology that underpins current modern manufacturing processes had not matured to the point that it could provide challenging problems for the university faculty body.

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[1] National Science Board, *Science Indicators 1981*; Ralph Landau, "The U.S. Position in World Markets: The Effect of Technology on Selected Industries", 50th Meeting of ABET, Colorado Springs, 1982; and Hearings of this committee "Role of Technology in Promoting Industrial Competitiveness" June 21 and 23, 1983.

Unfortunately, the university research community in Japan and the Federal Republic of Germany recognized these challenges earlier and appear to have made a greater commitment to the solution of manufacturing type problems. This head start may be attributable in part to the tighter linkage between industry and governmental institutions in the support of university research, and also to the existence of institutes which are committed to cooperative research efforts. It is in this regard that the provisions of S. 1286 are significantly whetted out, since the bill would encourage and support the development of joint industry research efforts. It would be my hope that the bill would sustain the existing manufacturing program and also support new centers as a means of supporting the development of new programs in manufacturing technology, since the capacity of the existing programs is inadequate for our Nation's needs.

In closing, I would like to call attention to the fact that while the Puget Sound area is one of the centers of technology intensive industries of the Nation, it also has its share of heavy industry which could profit from the activities which would be supported by S. 1286. The University of Washington is presently developing a graduate program in manufacturing systems engineering and jointly with the Washington Technology Center is seeking to develop a manufacturing technology research effort which would be concerned with computer aided manufacturing, robotics, artificial intelligence, and integrated manufacturing system. While substantial private support has been made available for the startup of the educational effort, the costs for implementing the research efforts are high. These costs must be derived from private and Federal resources.

In reviewing the history of the past three decades, I believe that S. 1286 would help overcome the lack of university research on manufacturing technology and would encourage more effective cooperative activities and technology transfers between industry and academe. The role of the university partner would be to engage in basic and applied research in manufacturing technology, and also to provide educational opportunity in manufacturing engineering. The role of the industry partner would be to participate and to fund these cooperative efforts and to undertake a commitment to implement commercially viable technology. The role of the Government would be to provide national leadership, to contribute generic funding in support of these cooperative efforts, and to seek and remove unnecessary legal constraints which inhibit cooperative efforts.

In the present form of S. 1286 I would only urge that the grants provided under section 5(b) of the bill would require an element of industry-university cooperation. I'd be delighted to answer any questions.

Senator **GORTON**. Thank you, Mr. Simpson. Thank you both for your testimony. I think you bring up an important point when you highlight the need for multiple responses to the problem of remaining competitive. I agree that there are a lot of pieces to the puzzle and a number of possible approaches.

Obviously, a sound economic climate is fundamental to our ability to innovate and to compete. Access to capital is necessary. Education and retraining in certain key areas is important. In building a sound technological base, strengthening research at universities and insuring a stable foundation for basic research is vital, as well. In this way S. 1286, for example, is only attempting to address one piece of a relatively large puzzle. Whether or not it's enacted, we obviously have to deal with each of the other pieces.

I'd like to begin by getting a perspective from each of you, as an individual businessman, on an issue which I've raised with Dr. Jay Keyworth, the President's Science Adviser. Do you feel that the United States is lagging in competition in manufacturing technologies which are relevant to your specific industries, as opposed to industry at large?

Mr. **MAYHEW**. Data I/O as a manufacturer is not very vertically integrated; that is, we do not manufacture much of the component level parts we use to our product. As such, it means that we do an assembly and a test function only. And I think that we are quite competitive with anybody in the world with regard to the productivity of our labor and the use of automated techniques. There's very little that we have not already done. The use of robotics for the insertion of components in servi-cards, for instance, is something that would not be available—economically sound as an approach to us until we get somewhat larger. But we are not reluctant to use that technique, it's just a matter of having adequate volume to justify. I do not feel that we are uncompetitive.

Now, in the manufacturing of components, were we to be a large enough manufacturer that we would consider a back-integration into the subcomponent level, then I think there are some areas where U.S. industry has some competitive problems. But in our own business, no.

Mr. **SIMPSON**. Unfortunately, Senator, we are somewhat parallel to Data I/O from the standpoint of a high labor intensive kind of company wherein we are basically nonvertically oriented, but we are an assembly type of company. While we are somewhat larger, the volumes involved in the production or the assembly of our products at this stage of the game would not benefit specifically by such exotic activities as robotics. What we have tried to do, as we have gone through the gestation period of growth, is overcome competitive edges that foreign competitors might have, by trying to be innovative in the motivation of our people and in the use of somewhat midgeneration automated activities that are available to all of us in the high technology industry. And by this I'm referring to automatic insertion devices for components and circuit boards, et cetera.

One of the problems that we do face, however, with foreign competitors is that there are several that are larger than we are, and therefore they do have the advantages of their developed automation assembly or manufacturing engineering techniques that we do not have available to us. I'm not saying that as a negative, Senator, because at this juncture, today, we would not be able to justify. But if I look out 5 years and no changes have been made, then I have a very significant problem. And perhaps by then the foreign currency translation loss problem will not be affecting us in those foreign markets, and we could meet this challenge of more sophisticated production techniques.

Senator **Gorton**. Mr. Mayhew, as part of your community service I understand that you chair the subcommittee on quality of engineering of the Washington Council for Technology Advancement. In that capacity, can you give me some insight as to whether or not there are serious shortages in the supply of engineers and technicians trained for the use of advanced manufacturing methods?

Mr. **Mayhew**. Well, the answer to that, Senator, would have to be yes. As you are aware, there is some controversy over the previous statements about the adequacy of supply of engineering graduates over the next several years. From my own experience, and I think you could verify this with the experience of people like Mr. Simpson and others, that when you try to hire the adequate level of qualified people today, we are beginning to compete with each other more and more, and it will grow more severe as the economy grows in health over the next couple of years.

The specific training of engineering people at the graduate level in manufacturing techniques is below that level that it should be. We find ourselves with—in fact, I verified this just this morning, my human resources director says that the most difficult category of labor to hire in our location is manufacturing engineering personnel, manufacturing test personnel. People to operate the complex equipment associated with our manufacturing process. And we are pretty typical.

Senator **Gorton**. How would we compare with our foreign competitors in that respect?

Mr. **Mayhew**. I find it difficult to comment. I haven't tried to recruit overseas in that area. Our company is not large enough to have a company, for instance, in a foreign location, where that would be a category that we would try to recruit. My travels, which are more frequently to Japan than it would be to probably any other area where we have competition, would suggest that the career outlook for a young engineering graduate in the manufacturing environment would be brighter in Japan than it would be here. That is, for a young engineer to consider his future or her future with regards to where they would spend it, most of the American young graduates would not think of the manufacturing area as desirable a future as in a laboratory or design of a product. And I can't explain why, but I believe that would be true.

Senator **Gorton**. Now, Mr. Mayhew, I'm going to give you an opportunity to go beyond the scope of this bill at this hearing, since you took that up in your testimony and advised that you would spend the money to discover why industry doesn't perform on its own, and stated that the reasons lie in the tax structure and incentives to modernize production processes, rather than the availability of technology. If you could simply get the Government of the United States to make two changes in those broad general areas, what would those two changes be?

Mr. MAYHEW. I, too, would like to be allowed to write you a letter later. I was an early recipient of a document back in 1980 when the Japanese MITI organization produced their vision of the 1980's, and was responsible for moving that document into the hands of the Board of the American Electronics Association and ultimately caused quite a furor about what it contained. I think that the Japanese Government has a good track record of understanding motivation of business, and moving in such a way as to ascertain what are the reasons why people either invest or don't invest in modernization. I think that although there has certainly been a degree of subsidy in the way in which they're related to business, that most of it has been to try and tailor the laws and taxes and the incentives associated with that environment to try and get them to do what they ought to do on their own. And I believe that there are some lessions to be learned there. But I would like to comment on that later.

Senator GORTON. OK, thank you. Mr. Simpson, a related question. In testimony before this subcommittee in Washington, D.C., on this subject, the President's Science Advisor and the Undersecretary of Commerce and International Trade pointed out that American industries have been slow to adopt advanced manufacturing methods, and that we lag behind Japan in manufacturing technologies and use. You pointed out that we can add the Federal Republic of Germany to that list. To what would you attribute that lag of our industries?

Mr. SIMPSON. I think it's attributable to the very reasons why "this bill is being considered. I'm not sure that it's totally a lack of innovative drive on the part of management, I think it's due to the fact that we haven't had a pool of trained bright young men and women who concentrate on this vital area of improved manufacturing efficiencies through automation. I don't know of too many CEO's in the Fortune 500 that came up through manufacturing. In other words, the highest percentage, if you analyze, came up either through finance or marketing activities, with some less extensive percentage through the manufacturing environment. And those of us who did not get exposed to the manufacturing process in either little or big companies tend to look for that kind of leadership in your submanagement levels who will propose and stimulate your thinking on how to do it better. That kind of talent has not been available, for the reasons that I pointed out in my testimony.

I think that—and this is not in total accord with my colleague—I think that management, certainly in the technology environment of our world of industry, is constantly seeking better and better answers, but that they're not going to generate nor are they able to generate them all by themselves. Being somewhat familiar with the Japanese motivational factors and one of the great booksellers of all time called "Theory Z," I take great exception to that, because that book could have been written prior to World War II by some of the leading companies in the Fortune 500 today. I think that, basically speaking, the motivational aspect of higher management in many of our technology companies is superior. But they need the kind of young input to be able to execute more effective techniques of manufacturing and more effective efficiencies. I don't know of any CEO's that go down to the plant and say, "I really think that application can be directed toward a whole new concept of programing a robotic."

So I put a great deal of emphasis on the importance of beefing up and expanding the educational process of this very vital and key discipline. I would look to the essence of this proposed bill as the Federal Government being the venture capitalist in a whole emerging technology that has been around passively, but needs to be highlighted and given great visibility if we are to proceed to attain the kind of goals that we will hope we can in moving the economy in a very competitive way.

Senator GORTON. May I ask you another question. Are there advanced manufacturing methods currently available in your industry that you are not using for some reason or another? And let me give you a related question, as well. To the extent that you could organize research, what kind of technologies would you want to concentrate on?

Mr. SIMPSON. As we attain our growth goals over the decade of the 1980's, it's obvious that we must have talent to be able to put less dependency on labor-intensive practices. Now, you could say, well, there are some very serious social implications in that statement, and yes, there are. If you look back to the decade of the 1950's and you find that computers were involved in a lot of interesting applications, there became an entirely new profession called programers and systems analysts. And so as we go through the decade of the 1980's, in our particular situation, in order to maintain a competitive posture against the Hitachis, the Nihons, Kodens, and the Siemens of this world, we will need to have that brain power in order to make us more effective. Whether it be robotics, whether it be superprograming capabilities in test and measurement, I can't write that script today. So that's one answer to part of the question. The other, Senator, is that in our industry today of the domestic companies involved, I would have to say that there is one leading manufacturer that in all probability is of the size that is probably making much more effective use of the level of sophistication in manufacturing engineering that we smaller ones don't. And I'm not being negative about that, it's just that they happen to be at the size to probably do a little more effective and advanced job.

But I go back to the basic underpinning of my concern and interest and support, and that is that it starts with the educational process of young men and women coming through our institutions of, in this case, higher education, to be able to come into the industry and offer this kind of support and this kind of technical capability.

Senator GORTON. Thank you both very much, you've helped us a great deal. The third and last panel will include Dr. Donald Root, Fredrick Blatt, and Mr. John Salathe.

Mr. Larry Smith could not be here today. We'll include Mr. Smith's statement in the record at this point, and we'll start with Dr. Root.

[The statement follows:]

STATEMENT OF LAWRENCE A. SMITH, PRESIDENT, LOCKHEED MARINE GROUP AND VICE PRESIDENT, LOCKHEED CORP.

Mr. Chairman: I would like to express my appreciation to this Subcommittee for an opportunity to comment on this pending legislation which is targeted towards enhancing the nation's attention to, and expanding research efforts on, the improvement of manufacturing technology. The premise which is the foundation and catalyst of this bill, S. 1286, is certainly demonstrable in the industrial sector which I represent. Shipbuilding in the United States has represented in many of its aspects the technological and the almost "institutionalized" inertia found in a great many of the country's manufacturing enterprises. I will take the liberty later in my testimony—in order to put the thrust and potential of the legislation in proper perspective as I see it—to comment on some other factors which also significantly contribute to American industries' lack of competitiveness edge—that is, elements of the problem which this bill alone will not cure, nor is its purpose to cure, and which are also fundamental, it would seem, to our problems vis-a-vis foreign competitive success.

Permit me first to address the specific questions posed in your letter to me, Mr. Chairman. Let me also indicate at the outset that, since we are all busy men, and admittedly, not authorities in all aspects of the complex problems addressed by this bill, that my testimony may be worth exactly what I am being paid for it. We will hope that is not the case.

America is indeed, in many of its industries, especially the so-called basic or smoke stack industries, not keeping abreast with the latest manufacturing technologies. Big Steel, for example, is a typical case in point. Some students of the problems plaguing some of our more basic industries have even suggested that the problems may be terminal and that there are certain arenas where perhaps we should not even try to compete! This, of course, poses new and ominous problems for the nation related to a permanently displaced work force—a problem which may not be cured substantially with this legislation, or any legislation, even if its root cause is in part precisely as cited in the proposed Bill. "Catch-up," as is often the case in ball games, is not always achievable.

However, on a much more positive note, in many production/fabrication enterprises there is a role that government, industry, and our universities can and I feel should pursue in fostering research and the application of new manufacturing technology. I would like to stress the term application. Basic research has a tendency all too often, especially as related to technology useful in the near-term, to be akin to the artist who paints an exquisite portrait and then runs all over the town to see if it looks like anybody.

Manufacturing Engineering, or what some call Industrial Engineering, historically has not shared the glamour of scientific breakthroughs so often associated with University Research Communities. Private industry's research efforts tend to favor products as opposed to production processes. We in industry tend to be in most instances very product oriented. Usually, we only begin to address or question our production techniques when we find we have a flawed product or an unacceptably costly product. This perception appears now to be driving the automobile industry towards much greater attention to quality. This is their answer to their competitive edge problem. It is now driving their changes in production techniques and even their marketing techniques.

Now, I would like to address some aspects of S-1286 and its ultimate application. First, if the grants to become available through passage of S-1286 are to be most effective in stimulating a truly productive manufacturing technology thrust in university programs, it would seem that those grants must provide for a very close link with the ultimate industrial users and beneficiaries. Even the most creative graduate researcher working in this somewhat unique technology area will be severely handicapped if he has not been exposed to, or lacks industrial guidance and experience in making certain that his energies are being dedicated to the right problem and workable hardware solutions. The loan of industry professionals with strong production backgrounds to university departments is certainly recommended and seems feasible. Many of the people long associated with production in industry would, I think, welcome an unfettered opportunity to really pause and without any deadlines or formal performance measures re-examine the way they are currently accomplishing their production tasks. I would like to suggest that the economies of private industry seldom permit such a research based luxury to production folks, no matter how desirable.

As regards that very vital experience factor for the student researcher or investigative team, we have found the availability of outstanding students from local institutions has worked extremely well in stimulating their interest in our particular enterprise. Many have later joined our professional staff. I suspect that without that study/work experience with us, that in all probability their last aspiration as a career goal was shipbuilding. I think that our experience with those students offers a clue for this legislation and its ultimate operational application that is invaluable. The university/industry barrier is superfical and appears to be one that can easily be broken down by innovative application of the proposed grants to foster such cooperative exchanges; i.e., loaned executives working intimately with faculties and students and the availability of graduates and undergraduates for appropriate work experiences. Great monies could and I feel should offer appropriate compensation to the student researchers, so necessary in today's costly educational scenario and also could compensate the industrial participants. It would seem naive to think that such a program will vigorously prosper and grow without some reasonable financial assistance to the players and their parent organizations.

As regards industry's access to, and the sharing of, evolved, innovative, manufacturing technology, it would seem that in administering the grants, such a stipulation should be a must, even though it flies in the face of the highly competitive character of most American enterprises. Such a stipulation seems justified, especially where the subject manufacturers provided none of the R&D costs, except through normal federal revenue channels. No two manufacturing firms will normally utilize evolving technology in the same time frame, nor are they often in identical capital situations as regards investment. Significant competitive factors always tend to survive. It would seem that sharing is generally desirable, expecially if the United States' industrial sectors most benefitted keep their emphasis on the us against them issue as their first priority problem. Certainly, the nation's medical practitioners have benefited greatly from the widespread availability of published data in their rendering of health care, data which emanates largely from the research community and is made available to all.

Nevertheless, with reference to Section 5. "Grants and Cooperative Agreements," this section may require language relating to those cases wherein an individual corporation contributes monies, equipment, or its talented personnel to expand the work contemplated under a research grant which protects, for a time at least, the results of the subject work being beneficially disclosed to the contributors' industrial competitors. This is a sensitive area of course which is immediately clouded by the infusion of federal monies. It is not thought to be the same magnitude of problem in the case of equal contributions to grant work made by Consortia, Centers or Industrial Associations. There is little doubt, however, in my mind that the Navy's Shipbuilding Technology Program and DoD's MANTECH Program suffer today from this technology sharing issue as much as from what appears to be cumbersome payback formula.

Focus or targeting of effort in a problem of such broad national magnitude and implication, expecially in the light of relatively limited funding, would seem to be extremely important, if we are not again merely to throw money at it. Considerable selectivity should be exercised by the Commerce Department in order to promote emphasis on those industrial and manufacturing areas that have had the greatest negative impact on American competitive posture and where breakthroughs in productivity, quality, cost and price, if achieved, can pay real dividends in both domestic and export market share. This no small challenge, but I think through existing documentation, prior and current industry studies and assessments of manufacturing associations, the Department can in the application of grants, focus on those industrial areas where the pay-off will be the greatest-soonest; that is, on those sectors where we are now in the greatest jeopardy from foreign competition or are soon apt to be in jeopardy.

Additionally, regional concentration of the research contemplated may be most important to the focus issue. Universities should probably point towards those key industrial sectors most dominant or economically significant to the community or region where they are located, where they enjoy greater ease of industrial access due to proximity and where the impact and contribution they can make will be recognized early and vigorously supported. The universities of Nebraska and Oklahoma, for example, should probably not seek to pursue shipbuilding technology as an industry target, even though in some basic areas, such as automation, they may make broad, multi-industry contributions.

As regards the processes and methods cited under Section 5 of S-1286, Shipbuilding is interested in all of the technologies cited and is already applying several of the technologies most productively. There is no doubt, even though we tend to be a labor intensive industry, that we at Lockheed Shipbuilding and our Advanced Marine Systems Division could potentially benefit from the proposed legislation and are favorably disposed to endorse its passage.

Since I reserved the right earlier to "extend my remarks," as they say on the "Hill"—I will refer very briefly to some other major contributors to certain of American industry's loss of market share—lest this legislation raise expectations not fully warranted. We, as a company, have recently made on-site visits to some 24 shipyards in the U.K., Sweden, Netherlands, Germany, Portugal, Spain, Japan and Korea. We observed a wide disparity in their production techniques, none of which are solely dominant in our shipbuilding industry's inability to compete. Indeed, some foreign yards are not that impressive, even when plant and equipment are newer and methods are modern. make no mistake, the biggest single factor is labor costs. Labor costs in Europe are now approaching our own and they too are starting to lose market share. This loss is also being borne out in European shipbuilding. Japan, Korea and ultimately the People's Republic of China are going to dominate commercial shipbuilding. In a non-assembly line process, such as shipbuilding, the labor rate differential problem, I predict, will not be overcome. That wide disparity, due to lower standards of living, foreign government subsidies and formal industrial policies will long prevail.

We here are making measurable strides in reducing our labor hour content. We have introduced advanced outfitting, automated material control, office automation, etc., but even with a heroic investment of capital and modern, innovative techniques, we cannot compete for commercial contracts in the world market. In quality and modern ship capabilities of course we can compete, but unfortunately at a premium price that operators in their ship acquisitions will not or cannot afford to pay.

People programs, quality circles, productivity rewards and profit sharing can and will play a major role in increasing productivity. We have adopted and are dedicated to such programs and the results thus far are good and measurable. Recent labor settlements, including our own, also indicate that labor and union leadership may finally be aware of their critical role in competition with foreign labor and industry.

Manufacturing Technology combined with both labor and management compensation restraints and productivity commensurate with the excellent remuneration being received, may ultimately permit major sectors of American industry to again compete domestically and abroad. However, I would be less than candid if I indicated to you that I felt the above applied to all industries, some of which indeed may be terminal cases. Because of that unpleasant fact, the nature of our industrial base may look quite different in the decades to come.

To compete in what is now a world economy, we must, and I hope we can, fix what is fixable and with some agony abandon what is not, unless it is critical to national defense and survival. Then perhaps we can get on with new and hopefully profitable enterprises where we are unbeatable or at least can be highly competitive.

Thank you again for permitting me to testify regarding this pending legislation. It appears to me to represent a step in the proper direction. It should however be approached with some considerable caution regarding its efficacy and should never become a legislative precedent which supports current infatuation with a national industrial policy.

I have avoided minute detail in my remarks and largely adhered to personal opinion in the areas under discussion. However, time permitting, I would be perfectly willing to answer any questions you may have to the best of my ability, Mr. Chairman.

STATEMENT OF DR. DONALD F. ROOT, DIRECTOR OF FIBER TECHNOLOGY RESEARCH AND DEVELOPMENT DIVISION, WEYERHAEUSER CO.

Dr. Root. Senator Gorton, thank you very much for giving me the opportunity to be a participant in this hearing. I think it's a terribly important subject area, and I'm glad to have the opportunity to be here. My name is Don Root, I'm director of the Fiber Technology Division, Research and Development, Weyerhaeuser Co. My technical training is in engineering, and for most of my career I have managed research and development efforts aimed at improving the technological competitiveness of my company, including various aspects of manufacturing technology. Relevant to the issues we are discussing today, I am engaged in several related activities. First, I am president of the board of directors of the Washington Pulp and Paper Foundation, which has the primary mission of establishing scholarships for students in pulp and paper technology at the University of Washington for career preparation in our industry.

I am a member of a subcommittee of the Washington Council for Technology Advancement which was referred to here several times already, and that council was formed to deal with issues concerning the technological competitiveness of the industry in the State of Washington. I would insert that my particular subcommittee deals with the issue of continuing education needs in the State.

I am a company representative to the Industrial Research Institute, a national organization made up of research executives which deals with the broad spectrum of problems and issues concerned with the technical health of the American industry. This includes cooperative efforts with agencies in Federal Government and with academic institutions.

The proposed bill addresses real and important needs relating to the U.S. competitiveness in world markets. There is no question that the United States is being severely challenged by foreign competitors in at least some of the areas of its manufacturing technology.

I am not sure, however, that the problem centers on a lack of basic technologic capability in the United States. I believe, rather, that key points requiring attention in dealing with this problem are as follows: First, the adequacy of supply of trained engineers of all types and, in particular, with respect to the scope of the context of this bill, engineers that have the multidisciplinary training required in manufacturing technology.

Second, and I intend to put my primary focus here, the adequacy of industry performance in undertaking programs of innovation to incorporate available manufacturing technologies into their operations.

Third, the adequacy of Government policies and actions in a macropolicy sense that insure a free and open exchange with foreign markets.

I will elaborate on each of these, but I'd like to make reference to testimony that was given in the Washington hearings on June 21 by Mr. Lionel Olmer and Dr. E. Bruce Merrifield of the Department of Commerce. I feel that their testimony was very consistent with my own views. In fact, I would suggest that Dr. Merrified be used in a very careful way in judging the appropriateness of this bill and implementing it, because from what I have seen and know of his activities, he is right on course with respect to the issues that we are facing here.

Now, let me first talk to the issue of the educational needs and the role of the universities in this problem. Several institutions are attempting to establish programs in manufacturing engineering offering degrees, usually at the masters level, in manufacturing systems engineering. I'm personally familiar with two such efforts, one at the University of Wisconsin-Madison, and the other at the University of Washington. These programs are difficult to organize because they involve the blending of several discrete—or viewed as discrete disciplines, including industrial engineering, mechanical engineering, electrical engineering, computer science, statistics and even behavioral science. One of the thrusts itself of the proposed bill where I would encourage relatively high emphasis would be to provide encouragement, perhaps in the form of seed money, to universities and other educational institutions that are endeavoring to establish such programs. That was referred to by others here several times already this afternoon.

As for the overall shortfall of engineers, I believe the committee should give proper recognition to existing efforts on the part of Federal and State Governments to bolster the efforts of engineering schools to enhance their capability of producing engineers. This is a fundamental issue and a concern in its own right which is broader than the narrow scope that we are dealing with here in this bill with manufacturing technology, but is basic to the total technological challenge that the Nation faces. In other words, if we solve the basic engineering supply problems, many of the more specific need areas, like manufacturing engineering, would also be favorably impacted.

With respect to industry's performance in doing its job to keep up with modern manufacturing technologies, I think it's fair to say that we have been asleep at the switch. Complacent, perhaps. Unfortunately it seems to take a competitive shock in the marketplace, such as we have experienced with the Japanses industry, to wake us up. There is evidence in the automotive industry that we are learning our lesson and that we do indeed have the capability to respond. The Japanese have more engineers per capita working in industry and they are superb at working relentlessly on the details of manufacturing technology, productivity and quality. Most of this is applications engineering, not fundamental research. In fact, they get the bulk of their fundamental needs met by gleaning results out of the rest of the world, especially the United States. They just apply it better. Part of the success of the Japanese is that they have a cultural system which encourages full and dedicated participation of all of the employees toward the common goals of high productivity and quality. We, in the United States industry, should not expect to emulate the Japanese culture in detail, but there are many elements of it that we can handle very well within our own system, and I'll cite four of them.

One is we can build a stronger technical skill base at all levels in our companies if the supply side of the engineering supply picture is adequately dealt with.

Second, there is a ground swell of change occurring in the United States in organization philosophy and design leading to more participative use of employees with fewer layers of bureaucracy and redtape in our corporations. This is quite different from the underlying cultural base of the Japanese, but it can have some of the same end results.

Third, the United States industry can make better use of modern techniques of manufacturing management such as quality work circles, statistical quality control, and other such things that have been developed so well in Japan, ironically, following the teachings of Edward Demming and Juran and others that did their basic work in the United States in the 1950's and before that.

Fourth, the U.S. industry management can adopt policies that would encourage greater risk taking and innovation, making better use of manufacturing technologies for which the scientific fundamentals already exist. This includes robotics, computer-aided manufacturing, automation, advanced process control, so forth.

The success of these opportunities depends, in my view, on establishing and maintaining a strong domestic and global economy. They are driven by economic opportunity which, in turn, is obviously a proper area for Government attention.

So what is the Government role? There is what I just mentioned, the response relating to the establishment of an economic environment which encourages innovation and growth. I am not expert in these areas, but it seems obvious that reduced inflation—which hopefully we have in hand—and interest rates are fundamentally required for the encouragement of technological innovation of all sorts. Another area of endeavor along these lines would be enhanced efforts to reduce international trade barriers to the export of U.S. technology and technologically dependent products. There may be other macropolicy areas, but the point is that the Federal Government can either inhibit or encourage management reforms, as well as research and capital formation, and it should be consciously pursuing the latter; in other words, encouraging rather than inhibiting.

More specific to this bill, the Federal Government could provide a positive impact through encouragement of university programs to improve the supply of engineers. It should also continue on the established trend of providing policy and financial support to fundamental and basic research, National Science Foundation and other such programs. Whether additional specific impetus is needed beyond these types of programs is hard for me to judge, because I don't have the total picture in mind. I do not believe, however, that the primary need in manufacturing technology for research is preferentially any greater than it is in the total spectrum of scientific and engineering interests of the Nation.

With specific reference to the bill, S. 1286, I would recommend emphasizing these aspects of the bill, these two:

First, the provision of funds to educational institutions that are engaged in programs leading to degrees in manufacturing engineering, or manufacturing systems engineering, as it's often referred to, with concurrent research in these fields. The primary purpose would be to enhance the supply of such engineers, and basic research would be the secondary purpose as it typically is in graduate degree programs.

And the second thrust that I would recommend is the support of research to obtain a better quantitative measure of the competitiveness of the U.S. industry in primary manufacturing sectors and to identify issues that might logically be addressed through legislation. And of course this is a provision of section 7(a) of the bill. My only concern about this aspect of the bill is that the Department of Commerce appears to be addressing the problem, at least in some ways, in its current programs.

I recommend relatively less or no emphasis in this bill on the formation of cooperative agreements or consortia to do applied research, with industry as coparticipants with the Federal Government. I feel this is the proper role of industry alone and, furthermore, that it would be more likely to succeed if kept in the normal free competitive maket context. Perhaps a carefully constructed exception to current antitrust restraints, as applied to the R&D area, would be worthy of consideration. And I know, by the way, Dr. Merrifield is pursuing proposals along those lines. In addition, I would raise the question whether the funding level proposed in the bill is enough to do any more than just sort of scratch the surface of applied research programs. Finally, I seriously question the efficacy of Federal-funded retaining of displaced workers by focusing on their retaining in the narrow field of manufacturing technology. Continuing education in a broader sense I think is a terribly important thing to pursue.

In summary, it is my view that this bill addresses a real problem, but that it will have only a limited impact without separate initiative on the part of industry. I would recommend a funding level for Government programs much lower than that proposed by the bill, perhaps 50 percent, a figure that seems comfortable to me, if we concentrated on the two very specific target areas that I've referred to in the foregoing testimony. Beyond this, continued focus on the economic environment is critical for creating the opportunities that will serve as an incentive to business. Thank you.

[The statement follows:]

STATEMENT OF DR. DONALD F. ROOT, DIRECTOR, FIBER TECHNOLOGY DIVISION, WEYERHAEUSER CO.

I am Dr. Donald F. Root, Director of the Fiber Technology Division, Research and Development, Weyerhaeuser Company. My technical training is in engineering, and for most of my carrer I have managed research and development efforts aimed at improving the technological competitiveness of my company including various aspects of manufacturing technology. Relevant to the issues we are discussing today, I am engaged in several important activities; (1) I am president of the Board of Directors of the Washington Pulp and Paper Foundation which has the primary mission of establishing scholarships for students in pulp and paper technology at the University of Washington for career preparation in our industry. (2) I am a member of a subcommittee of the Washington Council for Technology Advancement which was formed to grapple with issues concerning the technological competitiveness of industry in the state of Washington. (3) I am a company representative to the Industrial Research Institute, a national organization made up of research executives which deals with the broad spectrum of problems and issues concerning the technical health of American industry. This includes cooperative efforts with agencies of the federal government and academic institutions.

The proposed bill addresses real and important needs relating to U.S. competitiveness in world markets. There is no question that the United States is being severely challenged by foreign competitors in at least some of the areas of its manufacturing technologies.

I am not sure, however, that the problem centers on a lack of basic technological capability in the U.S. I believe, rather, that the key points requiring attention are:

1. Adequacy of supply of trained engineers of all types and, in particular, in this context, engineers with the multi-disciplinary training required in manufacturing technology.
2. Adequacy of industry performance in undertaking programs of innovation to incorporate available manufacturing technologies into their operations.

3. Adequacy of governmental policies and actions that ensure a free and open exchange with foreign markets.

I will elaborate on each of these and indicate how I feel the proposed bill can provide impact on the needs. However, I might interject that the testimony by Mr. Lionel Olmer and Dr. E. Bruce Merrifield of the Department of Commerce given at the hearings on this bill in Washington on June 21, 1983 are consistent with my own views. I would suggest that Dr. Merrifield's statement be given special credence because, in my judgment, he has an excellent understanding of the issues involved and, of course, has been actively engaged in efforts in the Commerce Department to help find solutions.

Let me turn first to the educational needs and the role of the universities in this problem. Several institutions are attempting to establish programs in manufacturing engineering offering degrees (usually at the Master's Degree) manufacturing systems engineering. I am personally familiar with two such efforts—one at the University of Wisconsin-Madison and the other at the University of Washington. These programs are difficult to organize because they involve the blending of several discrete disciplines, including industrial engineering, mechanical engineering, electrical engineering, computer science, statistics and even behavioral science. One of the thrusts itself of the proposed bill where I would encourage relatively high emphasis would be to provide encouragement (in the form of seed money perhaps) to universities who are endeavoring to establish such programs.

As for the overall shortfall of engineers, I believe the committee should give proper recognition to existing efforts on the part of federal and state governments to bolster the efforts of engineering schools to enhance their capability of producing engineers. This is a fundamental issue and concern in its own right (broader than the context of this bill) but is basic to the total technological challenge this nation faces. In other words, if we solve the basic engineering supply problems, many of the more specific need areas, like manufacturing engineering, would also be favorably impacted.

With respect to industry's performance in doing its job to keep up with modern manufacturing technologies, I think it is fair to say that we have been asleep at the switch. Unfortunately it seems to take a competitive shock in the market place, such as we have experienced with the Japanese industry, to wake us up. There is evidence in the automotive industry that we are learning our lesson and that we do indeed have the capability to respond. The Japanese have more engineers per capita working in industry and they are superb at working relentlessly on the details of manufacturing technology, productivity and quality. Most of this is applications engineering—not the generation of fundamental new concepts. In fact, they get the bulk of their fundamental needs met by gleaning results out of the rest of the world, especially the United States. Part of the success of the Japanese is that they have a cultural system which encourages full and dedicated participation of all of the employees toward the common goal of high productivity and quality. We in the U.S. industry should not expect to emulate the Japanese culture in detail, but there are many elements of it that we can handle very well within our own system:

1. We can build a stronger technical skill base at all levels in our companies if the supply of engineers is adequately dealt with.
2. There is a ground swell of change occurring in the U.S. in organization philosophy and design leading to more participative use of employees with fewer layers of bureaucracy and red tape. This is quite different from the underlying cultural base of the Japanese but it can have some of the same end results.
3. U.S. industry can make better use of modern techniques of manufacturing management such as quality work circles, statistical quality control, etc., which have been developed so well in Japan followed the teachings of Edwards Demming, J. M. Juran and others.
4. U.S industry management can adopt policies that would encourage greater risk-taking and innovation making better use of manufacturing technologies for which the scientific fundamentals already exist. This includes robotics, computer-aided manufacturing, automation, advanced process control, etc.

The success of these opportunities depends, in my view, on establishing and maintaining a strong domestic and global economy. They are driven by economic opportunity which, in turn, is a proper area for government attention.

What is the Federal Government's role? There is the aforementioned response relating to the establishment of an economic environment which encourages innovation and growth. I am not expert in these areas, but it seems obvious that reduced inflation and interest rates are fundamentally required for the encouragement of technological innovation. Another area of endeavor along these lines would be enhanced efforts to reduce international trade barriers to the export of U.S. technology and technologically dependent products. There may be other macro-policy areas, but the point is that the federal government can either inhibit or encourage management reforms, as well as research and capital formation, and that it should consciously pursue the latter.

More specific to this bill, the Federal Government could provide a positive impact through encouragement of university programs to improve supply of engineers. It should also continue on the established trend of providing policy and financial support to fundamental and basic research. Whether additional specific impetus is needed beyond the current programs of the National Science Foundation and other federal agencies is hard for me to judge. I do not believe, however, that the primary need in manufacturing technology for basic research is preferentially any greater than it is in the total spectrum of scientific and engineering interests of the nation.

With specific reference to S. 1286, I would recommend emphasizing these aspects of the bill:

1. The provision of funds to educational institutions that are engaged in programs leading to degrees in manufacturing systems engineering with concurrent research in these fields. The primary purpose would be to enhance the supply of such engineers; basic research would be the secondary purpose as it typically has been in most graduate degree programs.

2. The support of research to obtain a better quantitative measure of the competitiveness of U.S. industry in primary manufacturing sectors and to identify issues that might logically be addressed through legislation (as provided in Sec. 7(a) in the bill). My only concern about this aspect of the bill is that the Department of Commerce appears to be addressing the problem in its current programs.

I recommend relatively less or no emphasis in this bill on the formation of cooperative agreements or consortia with industry as co-participants with the Federal Government. I feel this is the proper role of industry alone and, furthermore, that it would be more likely to succeed if it is kept in the normal free competitive context. Perhaps a carefully constructed exception to current antitrust restraints, as applied to the R&D area, would be worthy of consideration. In addition, I would raise the question whether the funding level proposed in the bill is enough to do more than just scratch the surface. Finally, I seriously question the efficacy of federally-funded retraining of displaced workers by focusing on their retraining in the narrow field of manufacturing technology.

In summary, it is my view that S. 1286 addresses a real problem faced by our nation but will have only a limited impact without separate initiative on the part of industry. I would recommend a funding level for government programs much lower than that proposed by S. 1286 (perhaps 50 percent) with concentration on the two very specific targets indicated above. Beyond this, continued focus on the economic environment is critical for creating the opportunities that will serve as an incentive to business initiative.

Senator GORTON. Thank you, sir. Mr. Blatt.

STATEMENT OF FREDERICK M. BLATT, TREASURER, FASHION INSTITUTE OF TECHNOLOGY

Mr. BLATT. Thank you, Mr. Chairman, for the opportunity to appear on behalf of the Fashion Institute of Technology. My comments generally reflect the views of several manufacturers here in the Northwest, Paris Woolen Mills, C. C. Filson, Skookum, as well as the International Ladies Garment Workers Union in New York and the Skirt and Sportswear Manufacturers Association.

Before beginning my comments I'd just like to mention that I'm delighted to be back here in the northwest. I have lived many years in eastern Oregon. Though I must confess the weather today is somewhat different, it reminds me of the time I spent out there. Fortunately, after having been born and raised there most of my family decided to live in the Willamette Valley, so I guess I'm going to be going on a few trips back there, so I can look forward to that. My comments are going to generally elaborate on my written remarks I believe which were previously sent.

Senator GORTON. And will be included in the record in full.

Mr. **BLATT**. Thank you, sir. Just by explanation, the Fashion Institute of Technology has over 12,000 students enrolled, of whom about 8,000 are in continuing education. Mostly in what we like to call bootstrapping; that is, perhaps of the 8,000, two-thirds are studying in programs which have to do with upgrading their skills so they can either move upward within their existing companies or upward within the industry, or perhaps in some cases move laterally from jobs which have been made obsolete because of various changing technologies, and they thereby learn the skills to move into jobs which have perhaps become new for the first time.

Prior to becoming treasurer for the college I worked for more than 20 years in heavy industry, primarily steel and aluminum, and have the unique opportunity of having observed the manufacturing methods both of the hard goods and soft goods industries and also have observed research programs going on in various colleges.

What may not be recognized immediately is that there are enormous differences with respect to vitality of R&D in the hard goods industries as compared to the soft goods or apparel industry. Typically the apparel production manufacturer is involved in short-run production, with the exception of the manufacturers of jeans, or as they're called generically, Levis or Lee Riders, standard style pants such as the ones manufactured by Hagar, Farrah, undershirts and so on, which are produced by giants of the industry. The typical manufacturer produces a given style for a given season of the year, and then has to alter production capabilities to meet the constantly changing design requirements of the consumer.

It's literally a season-to-season business, and survival in one season does not necessarily guarantee or in any way indicate survival for a successive season. Any small problem can literally destroy a small manufacturer. About 2 weeks ago, by way of illustration, a manufacturer employing less than 200 people was burnt out, and he was unable to obtain alternate quarters, couldn't get the machinery, and just closed up. It's not necessarily typical, but on the other hand it's not atypical, because uncontrollable circumstances are of much greater critical importance to the small manufacturer than to the larger manufacturer.

Of the approximately 14,000 apparel manufacturers in the United States, very few, perhaps 15, employ more than a 1,000 employees. The vast majority of the manufacturers are the classic small businessman employing somewhere between 20 and 75 employees in a highly labor-intensive environment. Intense price competition from lower labor costs of offshore manufacturers renders it literally impossible for the necessary cash flow to be generated with which to mount research and development programs.

We have to contrast this with the Japanese Ministry of Trade action recently to fund automated production of men's shirts, which means that an entire nation is literally now beginning to attack, if I may use that word, a generally standardized production item, and the resulting effect on the small shirt manufacturer is potentially disastrous. Because once an industry is able to move into one item, whether it be apparel or hard goods, it naturally gives them the necessary cash flow and incentive to—this may be a bad analogy—spread their tentacles into other areas of industry.

The problem confronted by these small businessmen also generally is the requirement that with very short leadtime they are required to produce quantities of product. They cannot utilize their own raw material inventories that is required for the product they are going to manufacture itself primarily because they cannot determine in advance what the order requirements are going to be. The entire process, then, from initial design to product shipping is compressed into a remarkably short period of time. Where leadtime in airframe and automotive manufacturing is frequently expressed in years, in this industry leadtime is expressed in months. The time available for long-range planning or research and development simply doesn't exist. There is no leisure time, if one may call it that, during which the manufacturer may determine what he would like to do or where he would like to be some years hence.

The problems then confronted by the small manufacturer in this industry are not parallel to those confronted by the larger labor-intensive manufacturers. The small manufacturer requires the ability to produce a greater number of orders within a shorter period of time, and the only solution to that is technological improvements which will generate the necessary cost reductions to permit him to retain his competitive edge.

There are other technological problems which are more practival. For example, wool dying, which is done quite a bit here in the Northwest, requires heat, and therefore is energy-intensive. Even with the low rates that are charged by the BPA currently, they have still gone up enormously from the early 1960's. There is intense interest in developing a cold water process for dying wool, as that would reduce cost in the entire industry. But such research is beyond the financial capabilities of any individual manufacturer, and therefore, if it is being done, it is being done perhaps in one or two places, and that proprietary knowledge is not going to be shared. And I prefer not to get into the philosophical argument as to whether a small manufacturer then is going to be subject to normal competitive pressures.

The college has tried to make a small start in this field. We have, for example, starting with a modest seed money grant from Chase-Manhattan Bank, been providing free consulting services to small businessmen, mostly in the Northeastern United States, in an effort to improve their manufacturing and technological capabilities. Our research people, as well as members of our faculty, are constantly out in the field as part of their normal duties, and in a number of cases they have been fairly successful in developing computer-aided design and computer-aided manufacturing approaches which the smaller businessman on his own would have been unable to develop.

Similarly, in another area, we've been working with district 65 of the United Auto Workers in a joint program to provide technical computer education for its membership. We presently have at any one time about 200 members enrolled in this program. This provides reeducation for individuals who, as I mentioned earlier, might very likely become unemployed workers within the next 1 to 2 years, because the industry in which they are working is moving more and more to computer and terminal-based input and requires a certain degree of training in handling computers and computer-operated equipment.

It's our belief that S. 1286 will provide the capability to expend research and development capabilities, and does fill a void which has been left empty too long.

With respect to any changes in the legislation, our only view is that it is probably better to have the Department of Commerce operate under the flexible policy guidelines, which perhaps permits them the necessary flexibility to meet the changing requirements, as opposed to establishing more stringent legislative requirements which then, in order to meet the changing needs not now anticipated, would require perhaps lengthy legislative action. It's a welcome piece of legislation, we enthusiastically support its passage. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF FREDERICK M. BLATT, TREASURER, FASHION INSTITUTE OF TECHNOLOGY

I am Fredrick Blatt, Treasurer and Business Manager of the Fashion Institute of Technology. F.I.T., a college with a student enrollment in excess of 12,000, provides the necessary academic and hands-on training to prepare its graduates for careers in the apparel industry. Its Boards of Trustees include the president or board chairman of such diverse companies as Lord & Taylor, Saks Fifth Avenue, Bergdorf Goodman, Springs Mills, Anglo Woolens, John Weitz Inc., Calvin Klein Inc., and the International Ladies Garment Workers Union.

I welcome this opportunity to testify in support of S.1286, the "Manufacturing Sciences and Technology Research and Development Act of 1983," introduced by Senator Gorton and several cosponsors. This bill would establish research programs intended to produce and encourage the adoption of more efficient manufacturing technologies. Research grants, Centers for Manufacturing Research and Technology Utilization, and competitiveness studies are some of the means to the objective of S.1286.

The United States apparel industry, consisting of over 14,000 companies and employing in excess of 1,160,000 workers, is frequently overlooked during discussions of the development of more sophisticated manufacturing techniques and devices. All too often the emphasis is placed on hardgoods manufacturers, such as aerospace and automotive.

The Sewn Products-Fashion-Apparel Manufacturing Industry must deliver a product to the marketplace in a timely manner that conforms to specifications, looks good, and is competitively priced. Competition encompasses both domestic and foreign producers.

The survival of the domestic apparel industry is dependent upon the development, application, and implementation of state-of-the-art production technology. Members of this industry must utilize the most modern equipment in order to survive in today's fiercely competitive international markets. To do this, manufacturers must mount costly, time-consuming research and development programs to achieve necessary technology goals.

For example, there is a need to improve upon the industry's limited existing computer-aided design capabilities. This will result in a decrease in the time required for the planning phase of the manufacturing cycle. Result: competition is enhanced.

Generally, the major technological advances in the apparel industry are being accomplished by the giants in the field, both in the United States and overseas, particularly in Japan.

For example, the Japanese Ministry of Industry and Trade (MITI) has committed itself to funding the development of an automated materials handling, processing and assembly system for the manufacture of men's shirts. U.S. producers must create this same kind of manufacturing system to remain competitive. We can probably achieve this goal in less time than the Japanese if we do not wait too long to begin. Once this kind of system has been developed, the technology can be easily be expanded and transferred to the manufacture of other kinds of products.

The problem in achieving this goal in the United States is the financial structure of the industry. Of the approximately 14,000 apparel manufacturing facilities in this country, approximately ten companies (.07 percent) have the resources to engage in limited research and development. None of these ten companies have the financial capabilities to match MITI's effort.

Of the 1,160,000 employed in the apparel industry, approximately 80 percent are employed by small to medium-sized manufactures who do not have the financial capability to fund and support the research and development programs needed to develop more sophisticated manufacturing techniques. This leaves them in a distinctly unfavorable competitive position as compared to the very large manufacturers.

One of the attractions of S.1286 is that it provides improved research opportunities for both large and small manufacturers. The small can have access to needed production research, and the large can magnify their existing research capabilities.

Some of the smaller producers have suggested that the machinery manufacturers accept responsibility for development of the machinery that encompasses high levels of automated materials handling, processing and assembly. To a limited extent, they do develop some equipment that conforms to the aforementioned specification. The problem is that they will only invest in those projects that are quickly doable and will cover a large number of similar users. The result is the development of limited superior technology for a select group, for example, jeans manufacturers.

The equipment supplier has no desire to invest in technology transfer applications for the remainder of the industry because of industry fragmentation. They do not send enough units of sale to recover their investments. And these equipment suppliers do not fully understand the tasks involved in the fabrication of these other products.

Some might argue that government assistance in funding research and development is a form of protectionism, as it will assist American manufacturers in competing against the flood of imported products which has been washing over our shores for many years. However, the approach of S.1286 involves substantially less government involvement in the process than the protective and industry development practices of our competitors. I see it as the government helping business to help itself. A well-structured research and development program, as envisioned in this proposed legislation, will permit the smaller American apparel manufacturers to obtain the time so vitally needed to place themselves in a competitive position.

My interest in and support of S.1286 also grows out of the recognition by its sponsors that applied academic research, rather than pure research, is of great immediate importance to the U.S. industry. By way of example, F.I.T. has been closely involved with the apparel industry for several decades. Indeed, the apparel industry is responsible for the creation of the College in 1944. The capabilities of its faculty were developed not only through the academic process, but also through years of applied research and consulting to the industry. It is our view that one of the strongest points of this bill is its emphasis on the development of a team effort in which a college can join with one or more smaller manufacturers and, where necessary, call upon other institutions that are more highly technically specialized in order to develop workable technological advances needed by the industry.

To summarize, and reiterate, the most effective way to promote manufacturing technology research and utilization in the apparel industry is for consortia to be developed which will combine the expertise of development and applications specialist in computer-assisted disign and automated materials handling, processing and assembly with machinery and equipment manufacturers and companies in the Sewn Products-Fashion-Apparel Manufacturing Industry. S.1286 Provides this mechanism.

Working together, proper research could be implemented and technology would be developed and put in place in a timely manner. Programs would also be developed for educating the existing work force with the new skills required to operate and maintain this new equipment. Programs would also be developed for educating new workers for the specialized jobs that will be created. The competitive nature of the industry would be enhanced and its future assured.

Senator GORTON. Thank you very much. Mr. Salathe.

STATEMENT OF JOHN SALATHE, JR., VICE PRESIDENT, PACCAR, INC.

Mr. SALATHE. Thank you. My name is John Salathe, I'm vice president in manufacturing for PACCAR. I want to thank you and the committee for granting PACCAR the opportunity to testify before the subcommittee in support of S. 1286. The subject of research and development and the direction that the legislation is taking is an important issue to my company and the viability of this country's manufacturing base.

PACCAR is a multinational corporation serving customers throughout the world, it is one of the 200 largest manufacturing companies in America. The general public knows us best for the railroad cars of Pacific Car and Foundry and for Kenworth and Peterbilt trucks. But we are also recognized for the quality of our mining equipment, the Dart and Wagner product line, and our CARCO, Gearmatic, and Braden winches used in logging, fishing, construction, and the petroleum industries. We have a total of 16 manufacturing plants in the world, in Australia, Canada, Mexico, and the United States.

We believe, despite the perception among a great number of people, that industry and Government are not standing still in relation to expenditures in the area of research and development. Our country's total expenditure for private and public research and development is estimated to be $83.6 billion in 1983; that's compared to $77.3 billion in 1982. And if we reflect on the dollars spent by the private sector in 1979, the U.S. industry spent about $26 billion on research and development, which is about equal to what the industries or private research development was in France, Japan, and West Germany combined. But this doesn't mean that more can't be done. For example, our country's research and development expenditures as a percentage of GNP have declined since the 1960's. That doesn't mean we are standing still, but it means that expediture for research and development are continuing even through difficult times.

At PACCAR we believe that research and development is an integral part of our long-range strategic planning, and we are making financial commitments to insure this. In 1982 we invested $25 million in a new technical center in Skagit, and we believe this is a state of the art center for technical work on transportation. This facility encompasses 200-plus acres, has a 1.6-mile track, 30,000 square feet of office building with the latest in computer technology, and 110,000 feet in testing laboratories. We have budgeted close to $4 million in 1983 alone to test and assure the safety and quality of the transportation equipment we produce.

We feel still more has to be done to maximize the utilization of research and development expenditures in the United States. We believe S. 1286 moves in this direction by making funding available to industry, research associations and the academic community, in conjunction with cooperative agreements for these entities to join together in making expenditures on research and development with the goal of improving manufacturing technology. We commend you, Senator, and the members of the committee for the foresight of intoducing legislation that attempts to bridge the gap between industry and the academic sector of our society. We at PACCAR believe there has to be a better line of communication between the needs of the industrial base in the United States and the educational community fulfilling these needs. We are actively involved in the recently formed Washington State Roundtable where one of the top priorities is the relationship between those two major sectors of society, the academic community and the industrial community.

Pertaining to specific sections of the bill, I would like to direct my comments first to section 7 entitled "Competitiveness Studies." We agree with the intent of the legislation and the need of a study being undertaken to evaluate the long-term capabilities of specific industries for remaining competitive in relation to those industries' foreign competition. However, we would like to recommend that a representative or a number of representatives of the respective industry be an integral member of the evaluation of its own industry. We believe this will allow input from a domestic manufacturer of the future competitiveness of its own industry, and it will be an invaluable source of information for the study.

A second section of this legislation we would like to comment on is again under section 7, items 4 and 5, and I believe this was mentioned earlier. We commend the committee in requesting a study be done on the relationship of Federal laws and regulations as they relate to promoting technological innovation. The United States has been a champion of free enterprise, which is probably the main reason that it is the world leader that it is today. However, this philosophy has led to laws and regulations that have created barriers between competitive industries not apparent in other countries. This section of the bill requires an evaluation of the impact of specific laws and regulations on technological advancement in the United States, and we concur that such a study should be undertaken.

In conclusion, the last few months have not been business as usual for most companies in the United States. It is a time of intense international competition, with this country being confronted by formidable international counterparts who certainly have demonstrated the ability to compete. However, we at PACCAR place great faith in the imagination, the ingenuity, and the innovativeness of our employees. And in conjunction with proper incentives such as presented in S. 1286, we feel our company can remain a world leader. We thank you for the opportunity of letting us at PACCAR express our support for this legislation.

[The statement follows:]

STATEMENT OF JOHN SALATHE, JR., VICE PRESIDENT, PACCAR INC.

Mr. Chairman and Members of the Committee. I want to thank you for granting PACCAR the opportunity to testify before the Senate Science, Technology and Space Subcommittee in support of Senate Bill 1286. The subject of research and development and the direction which legislation is taking is an important issue to my company and the viability of this country's manufacturing base.

PACCAR is a multinational corporation serving customers throughout the world and is one of the two hundred largest manufacturing companies in America. The general public knows us best for Pacific Car and Foundry railroad cars and Kenworth and Peterbilt trucks. But we are also recognized for the quality of our Dart and Wagner mining equipment and our CARCO, Gearmatic, and Braden winches used in logging, fishing, construction, and petroleum industries. We have a total of sixteen manufacturing plants in Australia, Canada, Mexico, and the United States.

Despite a perception among a great number of people, industry and government are not standing still in relation to expenditures in the area of research and development. Our country's total expenditure for private and public research and development is estimated to be $83.6 billion in 1983 compared to $77.3 billion in 1982. Reflecting on dollars spent by the private sector in 1979, United States industries spent approximately $26 billion on research and development, which is roughly equal to all the private research and development spending in the countries of Japan, France, and West Germany combined. This does not mean to infer that more can't be done. For example, our country's research and development expenditures as a percentage of GNP have declined since the 1960s. But that does not mean we are standing still. Expenditures for research and development are continuing even during difficult economic times.

At PACCAR we believe research and development is an integral part of our long-range strategic planning, and we are making financial commitments to ensure this. In 1982 we completed construction of our $25 million Technical Center. This Skagit Valley testing center is the state of the art for a transportation testing center. This facility encompasses 242 acres consisting of a 1.6-mile oval track, a 30,000-square-foot office building, complete with the latest in computer technology, and 110,000 square feet in testing laboratories. We have budgeted close to $4 million in 1983 alone to test and assure the safety and quality of the transportation equipment we produce.

But still more has to be done to maximize the utilization of research and development expenditures in the United States. Senate bill 1286 moves in this direction by making funding available to industry, research associations, and the academic community in conjunction with cooperative agreements for these entities to join together in making expenditures on research and development with the goal of improving manufacturing technology. I commend Senator Gorton and the other members of this committee for the foresight of introducing legislation that attempts to bridge the gap between industry and the academic sector of our society. We at PACCAR believe there has to be a better line of communication between the needs of the industrial base in the United States and the educational community fulfilling these needs. We are actively involved in the recently formed Washington State Roundtable where one of the top priorities is the relationship between those two major sectors of society, the academic community and the industrial community.

Pertaining to specific sections of the bill, I would like to direct comments first to Section 7, entitled "Competitiveness Studies." We agree with the intent of the legislation and the need of a study being undertaken to evaluate the long-term capabilities of specific industries for remaining competitive in relation to those industries' foreign competition. However, we would like to recommend that a representative or a number of representatives of the respective industry be an integral member of the evaluation of its own industry. This will allow input from a domestic manufacturer of the future competitiveness of its own indutry, and will be an invaluable source of information for the study.

A second section of this legislation we would like to comment on is again under Section 7, Items 4 and 5. We commend the committee in requesting a study be done on the relationship of federal laws and regulations as they relate to promoting technological innovation. The United States has been a champion for free enterprise, which is a major reason it is the world leader it is today. However, this philosophy has led to laws and regulations that have created barriers between competitive industries not apparent in other countries. This section of the bill requires an evaluation of the impact of specific laws and regulations on technological advancement in the United States, and we concur that such a study should be undertaken.

In conclusion, the last few months have not been a "business as usual" mode for most companies in the United States. It is a time of intense international competition, with this country being confronted by formidable international counterparts who certainly have demonstrated the ability to compete. However, we at PACCAR place great faith in the imagination, ingenuity, and innovativeness of our employees and, in conjunction with the proper incentives, such as presented in Senate Bill 1286, our company will remain a world leader.

Again, thank you for the opportunity for PACCAR to express its support for this legislation.

Senator GORTON. I'd like to thank all three of you for being here and for helping us in this pursuit. I appreciate your testimony, because too often when we speak of the need to develop and utilize advanced manufacturing methods, there is a sense that we are speaking only of the so-called high tech industries, frontier industries. In your testimony, and I think Mr. Simpson's testimony as well, there's been a underscoring of the fact that all kinds of industries can benefit from the development and use of advanced manufacturing methods.

Particularly in your case, Dr. Root, I want to thank you for your suggestion that one thrust of S. 1286 ought to be in providing encouragement to universities which are endeavoring to establish programs in manufacturing engineering. That is, of course, the intent of the bill, to aid universities in establishing a stable source of funding for research programs and graduate students in the area of manufacturing engineering.

Can I ask you whether in your activities in the Washington Pulp and Paper Foundation and the Industrial Research Institution, what approaches to the supply of skilled manpower are being discussed or pursued? How are you reacting to this challenge?

Dr. Root. With respect to the activities of the Washington Pulp and Paper Foundation, there the primary mechanism is to provide tuition scholarships, and to recruit, from high schools and 2-year colleges, students into a program in the school of forestry focused on pulp and paper technology and very strongly tied to the chemical engineering school, as well. So it's really trying to stimulate the supply side of getting youngsters interested in our industry and to get those with demonstrated scholarship ability to choose careers in our industry.

Senator Gorton. What's your view of the relative responsibilities of government, Federal, State, and local, industry, and our university system in strengthening our research base and insuring the necessary supply of skilled people?

Dr. Root. As I've tried to indicate here, I put education ahead of research. Now, to do an education job, especially at graduate level, you have to do research, and there is no way you can manage a graduate school program in engineering or any other discipline without some concurrent research. But I put the primay emphasis on education rather than in the notion of research, which I think, especially in the applied areas, is best accomplished in industry.

So with respect to those three influences on the problem, Government I see playing the role of encouraging or even funding efforts to enhance the education programs producing engineers, and in particular in this context, in manufacturing. I think industry's role is to take a product of that effort and, within the total free competitive context, to do the applied research and to apply the engineering skills to the manufacturing problems. And the role of the educational institutions of course is to be the center or the base for the educational programs to accomplish this.

Senator Gorton. Thank you. Mr. Blatt, I was intrigued by your observation about the nature of the apparel industry and its resulting difficulties in funding research and development in these techniques. You suggested that this bill may provide improved research opportunities through the consortia mechanism. Are there any cooperative efforts involving Government, industry and universities currently underway at the Fashions Institute of Technology in research into the manufacturing process?

Mr. Blatt. Not developmentally. The New York State Department of Commerce funded a program perhaps 3 years ago. It was not addressed to those points specifically in S. 1286, it was more to the consulting area. That is, it provided a mechanism whereby smaller manufacturers could come to the college, and we, with our strong technological background, would be able to provide them with various consulting services. But there were more specific problems that had to be solved, generally in the material handling area. This is not an impossible problem work on, but the thrust in engineering has been to work on hard material. It seems to be more glamorous to do sheet steel than to try to figure out a way of moving a piece of polyester fabric.

But specifically in response to your question, there has been no research of the nature contemplated in S. 1286, as far as we are concerned. There has been some, we understand, at some other colleges, Carnegie-Mellon, perhaps, MIT. But there again, it occurs to be more along the lines of attempting to solve a particular need, and maybe something the Department of Defense would have originated.

Senator GORTON. Given the fact that a great number of companies in your industry are very, very small, would there be cooperation, would there be participation in cooperative programs if there were a mechanism for some kind of governmental match or for some kind of university participation? Are these necessary triggers to effecting research and development of new techniques in the soft goods industry?

Mr. BLATT. Pretty much so, yes. Rather than the individual manufacturer becoming involved, I suspect what would happen is the manufacturer would become involved through one of the various associations to which they belong. The small manufacturers generally occur to be apprehensive with respect to entering into any type of research program that is going to take time or money, both of which they have a very small supply of, unfortunately. So it's a very small supply of, unfortunately. So it's almost like being in a swamp full of alligators, it's very difficult to do any long-range planning.

Senator GORTON. So you really have to have some kind of outside incentive for this to take place.

Mr. BLATT. Yes, sir, from what we have seen in the areas we have involved ourselves in, that does generate enormous interest. They do come to the college and ask, and they do in most cases keep coming back, which means that we give them the answers they're seeking.

Senator GORTON. Mr. Salathe, I appreciate your specific suggestions with respect to S. 1286, and I was interested in your observation about the need for closer communication and cooperation between industry and the educational community. You commented that PACCAR is active in the Washington Roundtable. What kind of initiatives is the roundtable considering in order to improve that communication with the academic community, and how would this bill fit into that process?

Mr. SALATHE. Well, the roundtable recently was reported to have made some grants available to support a committee work in educational policies, to try to see what they can do to bridge this gap I think that's been addressed several times today, that there seems to be reluctance on the part of schools to start programs in manufacturing engineering. Again, our problems, of course, are different than the electronics industry, but there are techniques and implementation procedures in the technologies that need people to implement. And unless they are trained in this fashion, they can't help industry. So the roundtable as one of its goals has set up a committee to work with the education group between industry and see how can they bridge that gap of communication.

Senator GORTON. I'd like to thank the three of you, as I did the other participants. You've all been of great help in this most interesting and difficult work. Thank you very much. With that, the meeting is adjourned.

[Whereupon at 3:15 p.m. the meeting was adjourned.]

ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

TUESDAY, DECEMBER 6, 1983

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Birmingham, Ala.

The subcommittee met, pursuant to notice, at 9:30 a.m., in the Federal Courthouse, Birmingham, Ala., Hon. Howell T. Heflin presiding.

OPENING STATEMENT BY SENATOR HEFLIN

Senator **HEFLIN**. Good morning.

We appreciate Judge Lynn letting us use this courtroom for this hearing. The judge is allowing us the use of the building and maybe waiving a few rules about cameras and a few other things that they normally have. We appreciate that cooperation.

Today we begin hearings in Alabama on the role of research and technology in stimulating the economy and U.S. industrial competitiveness. This hearing is being held by the Senate Subcommittee on Science, Technology, and Space on which I serve as the ranking Democrat. Senator Gorton had planned to be with us. Senator Gorton is the chairman of this committee, but unfortunately he could not be here. Senator Denton could not make it either but will submit a statement for the record.

I could not think of a more timely topic for Alabama or the country as a whole. There is still a major unemployment problem, and we need to find ways to get people working again, and in productive jobs. We need to have our schools and universities provide an opportunity for our young people to learn the skills they need in those jobs. We need to keep our industries competitive in tomorrow's increasingly competitive world marketplace, and we need to figure out how the Government can work with industry and our schools in a cooperative fashion.

There are many ideas and proposals floating around in the country today and in Washington about what we must accomplish to get the U.S. economy in better shape. The States, the cities, business enterprises, labor, and universities are all trying to map out strategies to revitalize our basic industries as well as take advantage of the developing high technology. We have to invest in those new technologies that are keeping us competitive, technology in such basic areas as manufacturing as well as frontier areas such as space, lasers, electronics, computers, biotechnology, and many others.

I believe that whatever strategies we develop we will have to rely more on cooperative efforts among Government, industry, universities, and labor. I am particularly interested in cooperative approaches and have been looking into, among other ideas, the role of research parks. In a report released in May of this year entitled "The Federal Role of Fostering University-Industry Cooperation," the U.S. General Accounting Office, the GAO, which is not only the accounting and auditing arm of Congress, but also its study arm, reviewed cooperative efforts in science and technology nationwide.

In testimony the GAO will give tomorrow in Huntsville they will state that of the three types of cooperation they considered, the most dramatic contribution to innovation appears to be made by research parks which would enhance university-industry interaction at the frontiers of science and the leading edge of industrial technology. I know that people here in Birmingham are looking into this approach, and I would like to see what we can do to help.

This hearing will continue to gather information and ideas that should be helpful to the committee in its deliberation. We are still considering a bill, S. 1286, the Manufacturing Sciences and Technology Research and Development Act of 1983, introduced by Senator Slade Gorton of Washington, the chairman of our subcommittee and of which I am a cosponsor.

We have held 3 days of hearings already, and the hearings in Birmingham on university, industry, and Government cooperation will be particularly valuable. I look forward with a great deal of interest to hearing what our distinguished group of witnesses will have to say.

[The statement referred to follows:]

STATEMENT OF HON. JEREMIAH DENTON, U.S. SENATOR FROM ALABAMA

I appreciate the invitation from my colleague, the distinguished senior Senator from Alabama, to participate in the hearings being held by the Subcommittee on Science, Technology, and Space. I am pleased to see the Subcommittee consider such important topics as joint research endeavors among industry, universities and government, the establishment of research parks particularly in Alabama, and S. 1286, the Manufacturing Sciencs and Technology Research and Development Act of 1983.

I regret that I am not able to attend the hearings because of other commitments. The witnesses will, I am sure, make a major contribution to the discussion of the issues.

Our country is currently engaged in intense competition for a greater share of the world market for many products. The challenge of competition has caused a growing debate about how best to utilize our vast resources in order to generate industrial innovation in our basic industries and to create new high-tech industries.

The debate covers such diverse topics as the best means to coordinate efforts by industry, universities and government in order to promote research and development; how to create adequate incentives for further R & D; and how to improve training in math and science skills. A major question is whether the greatest responsibility should be with the private sector or with the government. Another question is the role of the federal government as compared with state and local governments. I hope that those questions will be carefully studied.

I believe that this is a proper time to discuss the role that research parks can make to the development of technologies and industries in our economy. The State of Alabama is blessed with fine universities and with a vast array of basic industries and high-tech firms, as well as with vast natural and physical resources. The record of such centers as Birmingham and Huntsville shows what we can do. I believe that our state can make a major contribution to the advancement of our nation and the world.

I look forward to reviewing the record of the hearings. Cooperating together, the private sector and universities, with encouragement from the government, can contribute to strengthening our economy, further developing our industries, and creating jobs for our citizens.

Senator HEFLIN. We are delighted that Congressman Ben Erdreich could be with us today, and at this time I am going to call on Congressman Erdreich to make any statement that he would like to make.

STATEMENT OF HON. BEN ERDREICH, U.S. REPRESENTATIVE FROM ALABAMA

Mr. ERDREICH. Thank you, Senator. I think I can do without the mike, so we will not have to move that. I want to just congratulate and appreciate your coming to our community and to the Sixth District. I think the look at cooperative efforts is what we should be about to make whatever dollars investment in the private and public sector regarding it.

About 4 years ago when I was a county commissioner we contracted with the Metropolitan Development Board here in this community to look at areas that should develop the best potential industrial opportunities, job opportunities in Jefferson County and in our metropolitan area. That study very clearly stated that the No. 1 area to look at would be the area of research park development.

We continued with that study to actually determine the parameters and potential of research parks in our community, and I think the single most—should not be amazing, but it was amazing to me—the fact was that already in place are some 10,000 jobs in this community in the research or technical area, and they come from our largest current employer which is the University of Alabama in Birmingham; and it is not coincidence it also comes from our next largest or about equal number of size of employment, the Bell Co. here which will be the affiliate of Bell South.

And you look at the scientific, technical areas, those clearly are the area of potential here, and this sort of inquiry that your committee is doing will give us both at the legislative level in Congress, but as well in the private sector here in this community, ways by which through cooperative interest, whether the University Medical Center, Rust Engineering, the Bell Cos., or what, ways to develop jobs in our community, to provide job opportunities, also, giving us the guidance that I think is needed to assure that we train folks for jobs that are going to be in place and not train people for jobs which are on a declining or nonexistent basis in our communities.

Whether you are looking at University of Alabama in Birmingham or those others, Rust Engineering or the Bell Cos. or what, the technical and service industries, that clearly is where jobs are here. We need to do more at every level to help create more job opportunities, and any cooperative industries through our university and scientific communities can only be a bonus, a plus for the future opportunity of Jefferson County and the entire State of Alabama.

One figure that I saw that keeps giving me more than a little pause indicates that Sun Belt growth for the next 20 years, and taking all of the States that comprise the Sun Belt, would be about 38 percent. The national growth rate is anticipated to be about 21 percent. Alabama's growth is pegged at about 12½ percent, and Jefferson County's growth is down at 7 or 8 percent in our metropolitan area right here at about 10 percent. Any way by which we can improve those numbers we need to be working long and hard at it.

I think again, you are to be complimented for the topic of this hearing, which to me gives us a real opportunity for new job development in our community, and one we all need to be a part of. Again, thank you for letting me participate, Senator.

Senator **Heflin**. Well, thank you, Congressman Erdreich, and we hope that you can stay, and as the witnesses testify feel free to ask them any questions that you would like to. I know that you have other obligations that were already made before you knew of this hearing, so I understand that you are going to have to leave. So we do appreciate it, and if you get any free time, we invite you to come back.

Now, a great number of witnesses have prepared written testimony, and there are copies of written testimony at the table here. If anyone wants copies of the testimony in a written form, you can pick them up at this time.

We have a pretty good number of witnesses to testify so we will start. We will adjourn about 12, depending on how close we are to finishing, and probably come back around 2. We do have some outstanding witnesses. We do hope that witnesses who have prepared their testimony in written form will summarize the testimony rather than read word by word from that written testimony, but give a summary of it.

Our first witness is Mr. Robert Colton, the program manager for Industry-University Cooperative Research Centers of the National Science Foundation in Washington.

Mr. Colton, we are delighted that you are with us, and we appreciate hearing from you at this time.

STATEMENT OF ROBERT COLTON, PROGRAM MANAGER FOR INDUSTRY-UNIVERSITY COOPERATIVE RESEARCH CENTERS, NATIONAL SCIENCE FOUNDATION

Mr. **Colton**. Thank you, Senator Heflin and Congressman Erdreich and the staff, and the others that are here. It is really a pleasure to be here to testify. Dr. Ed Knapp, the Director of the Foundation, expresses his regrets he is not able to be here, and he has asked me to come to discuss with you some of the work that we are doing at the Foundation that is involved with industry-university-Government relations.

As you know, the Foundation is a fairly large research organization. Our budget next year is going to be something over $1 billion, approaching $1.3 billion, and as you all know, most of our clientele are universities, and most of our funding is given on an unsolicited basis to the Nation's universities for basic research.

We are moving more into the applied areas as a complementary aspect, and more recently, that is, in the last 10 or 15 years, we are eliciting the aid of other components of the science and technology community such as the larger, the medium, and smaller businesses and institutions, to help us satisfy the needs of the Nation in developing a high level of competence in science and technology.

As concerning the important area that we are discussing today, the Foundation has, as I mentioned, in the last 10 years become more involved with industry and institutions, and over that period of time has developed a number of programs that we hope will stimulate industry, university, and Government cooperation.

I have written testimony which is available. I will be summarizing some of the activities we are doing now, and as a preface to that, I would like to mention that one of the major reasons why we at the Foundation are moving into the areas of trying to promote this kind of cooperation is that we feel there is a tremendous resource within the university—expertise, equipment, laboratory activities, and especially personnel who are developing new science and technology areas that are of interest to the industrial sector; and the cooperative efforts in this way will greatly improve upon our domestic as well as our international status.

We hope that over the last few years that the Foundation's work in this area is setting some examples, or at least paving some new ground for people to emulate, to come up with better ways of doing it, or at least to examine what we are doing from the standpoint of establishing new kinds of relationships between industry and university.

There are three specific programs that we have initiated over the last 10 years which I think are directly related to the areas of interest to this committee.

One we call the small business innovation research program. The second we call the industry-university cooperative research projects, and the third one, Industry-University Cooperative Research Centers. Each one has an industrial component, and each one to some extent involves the university.

As a sidelight, each and every one of these programs does have some degree of manufacturing science and technology involvement, both in the basic and the applied areas, and of course, this is of interest I am sure to the committee.

But let me in the next few minutes just quickly go over these three programs giving you some information of how they are constituted, what our budget is for them, and outlooks in the future. Then I would be pleased to answer any questions you might have.

The small business innovation research program was started in 1977 as an experiment in the National Science Foundation, whereby a group of the Foundation's people examined the possibility of having the higher technology, small business community participate in the activities of the National Science Foundation.

As a consequence, we set up a three-phase program whereby we would solicit on a competitive basis feasibility studies from small businesses. Small business is defined conventionally as something under 500 people, not a leader or major component of the industry who fits into the Small Business Administration activities.

The three-phase program, as I mentioned, consists of, first, feasibility studies where under this competitive basis we ask small businesses to send in proposals telling us of an area of science, research, or technology which they feel might have commercial applicability in the future. The successful awardees would receive

$35,000 from us in order to conduct this feasibility study over a period of possibly 6 to 9 months.

Following the conclusion of that first phase, a second phase would be initiated for those that appear to be well advanced in the feasibility studies. And the second phase could amount to $200,000 over a period of several years, during which time the feasibility would then be examined from the standpoint of is this the kind of thing that could be put into production.

None of our funds at the Foundation go into development or production because of our organic law. Therefore, in the second phase we stop short of having those funds used for actual development or production.

Although we do not actively participate in it the third phase is the most important part of our program. In this phase the venture capital industry will provide investment capital to those winners of first and second phase programs.

So at NSF the third phase really consists of following what happened to those businesses that received awards to see if in fact they get a following venture capital.

From the standpoint of what this program has accomplished you well know the Small Business Innovation Development Act of 1982 was passed requiring that the NSF experiment now be expanded to all agencies of Government that have an annual budget over $100 million R&D.

By 1987 there may be half a billion dollars of Government funds going into this program. The National Science Foundation's contribution will probably be more like $12 or $13 million because we are a relatively small agency funding in that area. But in any case, at the half a billion dollar level we expect thousands of businesses to receive awards.

But to bring you up to date as to what we have done so far as far as the National Science Foundation is concerned, we have made awards to about 400 or 500 companies in the first phase. About 50 or 60 have received second phase awards. During the 6 or 7 years lifetime of the program we have put in on an annual basis about $4 million or $5 million.

The venture capital that has been developed as a result of this, as of last year, has been over $50 million. These are private sector funds that have come into the small businesses that have received SBIR awards.

I would like to move quickly now into the second program which is our industry-university cooperative research project program, that is somewhat different than the first one, where we provide funds directly to small businesses. In this program we provide funds to a combination of a company and a university proposer who suggests an area of research that may fit into many of the areas the Foundation is currently interested in. It is a joint program. It is a joint submission where we stimulate and we solicit information and proposals from a company and university to suggest an area of basic research. We have an internal and external formula for funding these kinds of proposals.

Just for your information, the proposals that do come in are of the same type that are normally submitted to NSF from the universities. The peer review system is exactly the same as the conventional one. The major difference is a company and university submit a proposal on basic research.

We normally make about 100 awards a year. The program is now at the $7 million level and growing. We have over 300 companies now that are participating in this program.

The work that has been accomplished is published in the journals, is submitted to conferences, and is used extensively by the industrial participants.

The major objective of the program is to bring together industry and university people who have mutual interests, using the Government funding as a catalyst to set up an ongoing, continuing relationship.

This project's program is in essence a one-time funding operation. We fund a particular area of interest, and we presume that the company and university that originally received our award will continue to work together. But from the point of time that we terminate our funding, thus anticipating that the company would pick up where the Government left off and provide funds to the university.

This has happened to some extent, and because we are a National Science Foundation, we have set up an extensive tracking program to follow the progress of how the companies continue to work with universities after our funding has stopped. This information is not available now but will be available in several months as it is developed by our internal research people.

The third program is the Cooperative Research Centers program which is an older program. It was actually started about 10 years ago, around 1973, and its purpose was to help establish an organization that would have a very long term life.

The Foundation's goal was to provide initial funds for bringing together a group of companies, not one company as with the cooperative research project, but a group of companies with a university, all having a mutual interest in both basic and applied research.

The project's program is primarily basic research. But the center's program do combine basic and applied research.

Early on in this program, that is, in 1973 through 1978, we conducted a number of experiments with the university and as a result came up with what we think are some good guidelines as to how to set up centers. It primarily rests on the fact that one has to find a very good leader, a strong personality, an expert in the field at the university who could inspire cooperation and participation from the private sector.

As I said, based on our experimental work during the first 5 years, 1973 to 1978, we came up with guidelines for establishing a whole series of centers, and as of this day we now have about 12 operational centers that have progressed to various stages of development. We have about six or seven planning centers that in fact may develop into operational centers in the future.

From the standpoint of how this program is growing, the funding for this fiscal year is now at the $3 million level.

Senator **Heflin**. Staff from the chairman of the subcommittee has now arrived. Maybe the technology was welcoming you. We are delighted to see you.

Go ahead, sir.

Mr. COLTON. We anticipate that the program will be growing at a moderate rate during the next few years, and because of the way we can leverage funds in this program, we anticipate that within 2 years we may have as many as 40 centers, possibly 20 to 25 in the operation phase, and another 15 in the planning phase.

If you remember, I mentioned that we tried to work from a leveraging standpoint. To give you some examples, the center's program which now operates at about $1½ to $2 million a year bring in about $6 million of cash, of hard money, from the various companies that are participants. So we have about a 4 to 1 return on investment if you look at it from a business standpoint. The industrial funds go directly from the companies participating to a particular university.

In addition to that, equipment, in-kind services, and other aspects of industry participation with the program amount to another $6 million. We do not even count that, but we do mention that in fact there are other aspects to this program.

From the standpoint of interest of this particular hearing, we have four centers now that in one form or another do deal with the manufacturing sciences and technology—and I would like to just briefly state what they are and then talk for a minute or two about some of the activities that we are engaging in here in Alabama. Then if you have questions, I will be glad to answer them.

At Rennselaer Polytech we have an extensive program in computer graphics, CAD-CAM, which is one of the areas of interest from manufacturing technology. At the University of Rhode Island we have a major program in robotics. At Georgia Tech we have one in materials handling, and at the Worcester Polytechnical Institute in Worcester, Mass. near Boston we have one in automation technology. All of these programs encompass both basic and applied research in many of the areas of manufacturing and industrial technology.

Lastly, I would like to mention that over the last 6 to 8 months we at the Foundation have been dealing with two groups here in Alabama: Tuskegee Institute and the University of Alabama in trying to arrange for cooperative centers that are respectively in agriculture, and in the manufacturing technology area.

The agricultural one is with Tuskegee. I am not sure how that will progress, but we are talking with them.

The one that is concerned with manufacturing technology at the University of Alabama is also concerned with setting up some experimental programs and some research activities at the university which have to do with what is called the "Factory of the Future." This is a development by the General Motors Co., their Rochester Carburetor Division, the United Auto Workers, and the University of Alabama.

We are hoping that if enough companies can be brought into this organizational structure, and if it does suit the needs of the Cooperative Research Center, we can help to establish such a center here in Alabama.

At this point I would like to cease my remarks and answer any questions.

Senator HEFLIN. Ben, do you have any questions?

Mr. **Erdreich**. I will take a few, Senator. I have to leave in about 10 minutes to make another meeting.

I appreciate your comments, Dr. Colton. I was curious, you said you award about 100 yearly awards on the industrial-university cooperative activities. Could you give me some idea of what, just maybe a typical or an atypical activity in that area where a single industry, as I understand it, would be cooperating with university basic research, is that correct?

Mr. **Colton**. Yes; it is concerned with basic research. Some are in the area of processes, some in instrumentation. Chemical processes may be one example, that is, very sophisticated filtering devices, for instance, or a new type of instrument for examining structures. An ion microscope might be an example.

The program gets into most every area of engineering, mechanical, chemical, electrical, et cetera. More often than not, the companies participating are the larger companies because those are the ones who can provide the major funds for this. There are very few smaller companies, and this is one of our concerns. And in fact, what we have done, of course, is tried to expand upon the small business program which is the other one I mentioned, to make up for their lack of involvement in the project's programs.

Congressman, I have a whole list of all of the areas, and I also have some slides showing the various universities and companies involved, and if you would like me to submit those as part of my testimony, I would be very pleased to.

Mr. **Erdreich**. If I understood, it was a one-time funding.

What would be a typical funding block in that program, or does it vary?

Mr. **Colton**. It varies, but the typical funding would be around $100,000.

Mr. **Erdreich**. Is the effort either of that particular involvement with the university and industry cooperation and/or the centers, and maybe even the third, which is your small business innovation centers, have any of those been tied into developing a new research park effort?

Mr. **Colton**. Not specifically. The foundation has not been involved in the development of parks, although we feel that some of our activity may provide that sort of stimulation. One specific example, now, that may result or help result in the development of a park is a program that we are considering now at the University of Texas Health Science Center in San Antonio. They are trying to put together a major complex in bioengineering and biotechnology. They are hoping to arrange for some sort of a park activity, and it is possible that one of the major components of that will be a cooperative research center that we may help them plan a center in molecular targeting.

So even though we do not directly participate in starting a park, some of the centers we are studying may end up as being the kingpins of a research park, where companies and universities are brought together right at the very beginning.

Mr. **Erdreich**. By bringing them together helps create something beyond——

Mr. **Colton**. Maybe a spark that allows this to happen, and Dr. Money I am sure will reinforce this, but one of the main things I individually feel about research parks is that they should start immediately on a cash flow basis. There ought to be something in there that immediately has income.

Mr. **Erdreich**. That there is a commercial reality——

Mr. **Colton**. Whatever it might be, I think it is important that one starts from that context, and starting a center may be a proper mechanism for that type of initiation.

Mr. **Erdreich**. And just my last question, your small business innovation, one of the criteria is looking at commercial application and the feasibility studies that you do, the initial study is to try to determine whether indeed there is real commercial application.

If I understand it, the other two are basic research related and some applied research, is that correct?

Mr. **Colton**. Yes, they are, but the small business one is also a combination of basic and applied research.

Mr. **Erdreich**. In looking at the potential for commercial application of that?

Mr. **Colton**. Yes; one further thing, just to enlarge a little bit on your question: You remember I mentioned the program that is expanding significantly into other agencies. The National Science Foundation does tend to fund the more basic research areas, so you will find that the small companies responding to our solicitation will be those that are more adept at basic research.

As we get into the Department of Defense and the Department of Transportation, EPA and others, you will find that the solicitations that are put out by those agencies may very well get more into development, so that the small business community that will be impacted as a result of the expansion of this program may cover the whole gamut of research activities from basic all the way to development and possibly even testing.

Mr. **Erdreich**. Thank you very much.

Thank you, Senator, for letting me participate in the hearing.

Senator **Heflin**. Well, thank you, Congressman Erdreich.

You have outlined the role that the National Science Foundation plays, and of course, your Industry-University Cooperative Research Centers are bringing together a number of different industries and universities, or a university or universities together.

The research park, I suppose, is a more formalized center, more of a location, with physical structures and things of this sort. It would seem to me that the first program that you you have is a number of cooperative research projects going on and they can aid in the establishment of a center. If a university has several different research projects going on with different universities, or perhaps even several with even the same industry, it could be that that would be an incentive toward developing and moving toward the research center and could provide some cash flow if it has reached the stage of commercialization.

Now, in order that maybe some people here might understand it, we will say an engineering firm is interested in an engineering school, perhaps maybe doing certain experiments and doing certain developments. Maybe there is a machine or something that is extremely expensive. The center does not want to buy it; the university does not want to buy it; but by a three-part participation, purchase of that machine could be arranged with the National Science Foundation.

But really, you do not anticipate any long-range participation in the funding, but rather as seed money in the beginning, is that a correct understanding?

Mr. **Colton**. Yes; one of the major principles we have in dealing with industry-university relations or industry in general is that the Government's function is to initiate these sorts of programs and let them build on their own so that they will entirely be taken over by the private sector.

And your first observation about how the individual project could lead to a center is a very astute one. As a matter of fact, we have several university-industry cooperative projects that may very well lead into centers. And of course, you are quite familiar, I am sure, with the center program in your cosponsorship of the Stevenson-Widler Act. You had a lot to do with that. In fact, you probably also know when the act was finally passed in 1980, from that time on we have been reporting all our center activities as being responsive to the Stevenson-Widler Act.

Senator **Heflin**. Well, it could stand more proper funding, these innovation centers. We want to pursue that along with this bill, I think. It has some potential.

I am interested in what you have told us about the factory of the future, of which Alabama is already participating. There is a grant from the National Science Foundation with the University at Tuscaloosa, and you have General Motors and Rochester Carburetors.

Mr. **Colton**. It is the Rochester Carburetor Division of General Motors, and they have a plant locally that they were considering closing down, I understand, until there was an agreement made between the UAW and the university and GM about establishing this factory of the future which would examine many materials handling, automation, and manufacturing technology areas as a means of improving both the manufacturing and the actual production of the carburetor components.

We have not funded this yet, but we are in a position now of working with the principals at the university to see if, in fact, the program can develop.

Senator **Heflin**. Are there funded projects in Alabama right now by the National Science Foundation?

Mr. **Colton**. Yes; there are, but I do not have them at my fingertips.

Senator **Heflin**. You do not have them before you?

Mr. **Colton**. I will find them out.

Senator **Heflin**. The concept of the Birmingham Research Park would be to build it in a rather centralized location with close proximity to a number of universities and to a number of industries.

Auburn University, which has done a great deal in agriculture and engineering and other aspects; Tuskegee, of course, from Dr. George Washington Carver, who we all know of his type of research; and then the University in Tuscaloosa of Alabama, the University in Birmingham, and the University in Huntsville, all are in close proximity.

Sometimes we here in Alabama think that 50 or 100 miles is a great distance, but I have noticed in Washington and elsewhere that that is almost considered commuting distance from home to work sometimes. I have not been able to fight it yet myself, but there are people that do it all the time.

So, with this in mind, if these individual universities with their various industries and their strengths could endeavor to bring together industry and their expertise in their various universities, start with them, and then enlarge into a research park, it would, I suppose, be very helpful.

I believe that you publish a manual, according to your testimony, you publish a manual on the research centers.

Mr. COLTON. Yes, sir.

Senator HEFLIN. And perhaps a practice manual, I think, based on your experience, and there may be some people here that would like to see copies of these manuals, and if we are contacted, maybe we can act as a clearinghouse by which these manuals might be made available.

We appreciate your testimony.

Would any member on the staff like to ask some questions?

Thank you very much, Mr. Colton.

Mr. COLTON. Thank you very much.

[The statement follows:]

STATEMENT OF ROBERT M. COLTON, PROGRAM MANAGER, DIVISION OF INDUSTRIAL SCIENCE AND TECHNOLOGICAL INNOVATION, DIRECTORATE FOR SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and members of the committee, I would like to thank the committee for the invitation to testify on the NSF role in university/industry/Government research and development. In my remarks, I will describe the foundation's programs of industry/university cooperative research, small business innovation research and their respective budgets.

I. INDUSTRY-UNIVERSITY COOPERATIVE RESEARCH

Background

Industry-university research cooperation is clearly a national trend. This relationship represents an active partnership aimed at reenergizing the innovation and productivity of the U.S. industrial machine that has been the model for the free world. They are cooperating to meet the scientific and technical challenges posed by our domestic needs as well as international competition. Interest in industry-university cooperative research is now more intense because of the growing perception that industrial products and services are increasingly dependent on fundamental scientific understanding.

This industry-university relationship is now seen as a powerful new force aimed at stimulating U.S. innovation and productivity. A recent National Science Board report on university-industry research relationships provides much detail on the cooperative relationships that presently exist. I would like to provide a copy of that report for your information and for the record of the hearings.

The National Science Board report suggests that there is a general consensus on the likelihood of increased university-industry research interaction in the 1980's. According to the report, new arrangements reflect an optimistic mood that is grounded in an awareness that the problems and opportunities in technologically based industrial production are substantially different from those of the past. Three general factors characterize this change.

First, product, and process improvement, and innovation in some industries have evolved to levels of complexity that demand understanding of fundamental physical and biological phenomena and, thus, require much higher levels of training in and use of basic science and engineering. One factor contributing to increased complexity is that manufacturing is becoming a process-oriented activity and requires much greater involvement with the fundamental properties of the materials being worked. For example, in microelectronics, as the manufacturing of microcircuits is pushed down to even smaller dimensions, puzzling phenomena occur which require new scientific and engineering explanations before further progress can take place.

Further, incremental advances in narrowly focused technical areas, characteristic of much industrial development in the past, are giving way to the use of a broad range of science and engineering disciplines on complex, often ill-defined problems, or exploitation of new analytical capabilities. Hence, it is becoming increasingly difficult for any one industrial laboratory to fully encompass the requisite expertise. A partial remedy for this situation is to seek out the pertinent skills wherever they may be found in the nation's universities.

And finally, the rapid expansion of the Nation's R&D system over the past three decades has diffused research capabilities over a much broader range of institutions—academic and industrial—than before. Thus, it is quite unlikely that any one company could hold and maintain a leading edge on technical advance in a given area as, for example, Du Pont was able to do in polymer fibers during the 1930's and later.

These changes are interactive, and we may see these factors converging to create new configurations of academic and industrial research.

NSF program

A major theme of NSF industry/university research programs is the lever-aging of non-Government scientific and financial resources and focusing them on the goal of stimulating unique research that can lead to technological development. Current NSF programs designed to accomplish these objectives include: Industry/university cooperative research projects; university/industry cooperative research centers; and small business innovation research. The cooperative research programs provide mechanisms intended to encourage collaboration in research by academic and industrial scientists according to their own research priorities. Small business projects provide another focus for the leveraging of human resources in that their is significant involvment by university researchers on a consulting and often a graduate training basis with new research-based companies.

Industry/university cooperative research projects

The industry/university cooperative research (IUCR) projects program encourages and advances scientific knowledge, which is relevant to industrial technological innovation through the means of research cooperation between university and industry researchers.

Cooperative industry/university research projects focus on fundamental questions of science and basic engineering underlying future technological advancements. It does not support commercial product development. Research proposals are jointly developed by scientists and engineers in universites and industrial firms. Cost sharing by industry is required and provides a mechanism for assuring that research topics have industrial management interest. Each project utilizes the unique capabilities of both participants and synergism results in a better research project than either could do alone.

The management of the program is decentralized between the IUCR program and the research divisions of NSF. The IUCR program provides oversight on the projects to insure strong research cooperation, technological relevance, and incentives to encourage cooperative research. The research divisions provide technical review and project selection. The research divisions, in consultation with the IUCR program, rank cooperative projects as to the quality of research, importance to science, importance to technology, and significant research collaboration. The research division and the IUCR program then agree to split fund the research for the duration of the project.

Cooperative research projects occur most frequently in the science and engineering areas which are directly in contact with industrial technology. They are both fundamental in advancing scientific frontiers and technologically important in deepening and expanding the knowledge base upon which to build new technology. The industrial problems provide university researchers with challenging fundamental problems; while the academic perspective encourages industry to try more fundamental approaches than industry is accustomed to use.

The distribution of IUCR funds has been about half to the science divisions and about half to the engineering divisions. This distribution has followed proposal pressure, modified by a program goal to involve the science fields in cooperative research, as well as the engineering fields. The reason for this goal is that basic research in engineering is normally relevant to the middle-term technological changes in industry, while basic research in science is normally relevant to the long-term technological changes in industry. As for the short-term changes, industry normally takes care of this, itself. The university/industry research connection is, therefore, for the middle-to-long-term research needs of industry.

IUCR budget for fiscal year 1984 is $7 million, which indicates that at least $14 million from NSF will be obligated to cooperative research. In addition, an expected $14 million will be spent by participating firms on their own research participation, providing a significant leveraging of Federal research funds.

Cooperative projects in the science areas investigate the phenomena underlying important technologies, and in the engineering areas, cooperative projects investigate the basic principles in designing industrial devices, processes, and materials. In both areas, new technological feasibility and scientific instrumentation are often created.

As an example of phenomena underlying important new technologies, Professor Tanner at Ohio State University and Dr. Epstein at the Xerox Webster Research Center are studying the mechanism of electrical conductivity in the newly discovered conducting polymers. They are asking the fundamental question of:

1. Why these polymers, such as doped polyacetylenes, have electrical conductivity ranging from insulator to semiconductor to metallic; and

2. How electrical conductivity occurs in these doped polymers. A fundamental understanding of the conductivity will allow the design of polymeric materials with desired properties. At Ohio State, Professor Tanner has facilities for sensitive spectroscopic studies; and at Xerox, Dr. Epstein has equipment and skills for synthesis and characterization of the new materials. Currently in industry, much research in conducting polymers is being directed at making batteries entirely of plastic, which will be lighter and more durable than lead batteries.

Industry/university cooperative research centers

A second program is the industry/university cooperative research centers program, that stimulates industrial support of university research through the establishment of centers to create long-term collaboration between the university and industry in research areas of high mutual interest. This NSF program, with cofunding from groups of industrial companies, initiates university research centers that are responsive to industry's research needs yet compatible with the research objectives and standards of the university. Industrially relevant research at the university results from the exposure of faculty and graduate students to industrial interest and needs. Concurrently, industry benefits by exposure to university research capabilities and interest.

Industrial support and utilization of university research is a major program goal. Research programs of the centers correspond to the university's scientific and engineering areas of expertise. The centers have an interdisciplinary research program to meet industry's research needs. All centers must increase the industrial support for their research program as NSF support is phased out within a period of 5 years. A center is considered a success when its research funding is at its original level or higher and NSF no longer provides support.

A key to the program's success is the fact that the Government or, more specifically, NSF does not determine the area of science or what industrial sector is to be addressed. The program emphasizes local autonomy and separate development; each center develops along its independent path determined by the university capabilities and interest and industry's needs and interest.

In order to avoid commitment of scarce NSF program funds to a center concept that is not fully developed, we require the university to start with a 1-year planning grant during which time they study and develop their research and management plans and, at the same time, determine the industry's research interest and willingness to support the proposed center. Each center that has been started or is in the planning stage has been suggested and/or coordinated with NSF program managers in the scientific disciplines involved. Thus, the center program augments the scientific research support thrust of other NSF programs.

After successful completion of the planning activity, a second proposal must be submitted by a "potential" center for an operations grant. This second grant could cover an additional 4-year period with NSF funding totaling up to $750,000, but gradually being reduced during the 4 years. At the conclusion of the NSF funding, the center would be self sustaining and entirely funded by industry. Currently, we are funding or have funded 12 operational centers in such areas as polymers, computer graphics, welding, robotics, telecommunications, ceramics, materials handling, automation technology, hydrogen technology, and dielectrics. In addition, we are currently funding eight planning grants in the areas of toxic waste, analytic chemistry, clean room technology, steel processing tribology, Electro-optics, monoclonal antibodies, and steelmaking. By the end of 1984, we expect to have about 20 operational centers with an additional 12 to 15 planning grants awarded during fiscal year 1984.

The most critical element in the university's management role is that of leadership. The center leaders must be recognized scientists who have the entrepreneurial talent and the drive to work with the university management and the marketing ability to work with industry representatives. Leadership ability is also required to attract university faculty and graduate students to take part in industrially relevant research.

The university interface with NSF and industry is one that changes as the role of NSF diminishes and the role of industry increases. As new companies are added and the industry interest solidifies, the university must be responsive to industry by aligning their research goals within limits they feel are appropriate.

Industry's financial support is a major goal of the NSF program. We see an increased awareness on the part of individual companies of the value of pooling their research dollars with other companies. In a typical center they have access to 600,000 dollar's worth of research for a $30,000 investment.

Center membership requires more than financial support, however. It requires active participation in the center by industrial leaders. They must provide qualified researchers to monitor the scientific progress of the research and top level managers to act as advisers on management and operation of centers. It is this industry management role that guides the research and determines the industrial relevance.

The process of initiating and operating a center is a complex social process, and the success of a center is more than just a function of scientific merit and dollars. All of the thriving centers are both centers of scientific excellence and healthy social organizations with regard to industry/university activities. A great deal has been learned about centers and industrial support of them. A practice manual based on this experience has been published. I would like to provide a copy of the manual for your information and the use of the committee.

The accomplishments of the centers program have been manyfold. They have led to stronger and more effective interdisciplinary university research programs with industrial relevance. The amount of NSF and individual company funds required have been minimal. The students coming out of the program are well rounded and ready to assume their roles in industry upon graduation. The most important and long-term result of all these accomplishments is the coupling of fundamental research to technological utilization. This is critical if American industry is to increase its leadership in world markets.

Benefits and problems of cooperative research programs

There are some obvious benefits of cooperation between university and industry researchers. First, these programs leverage Federal funds. Overall industry funding of university research now stands at less than 4 percent of the total funds, compared to nearly 70 percent for the Federal Government. Anything that can be done to increase industry participation is in the national interest. Second, industry/university cooperative research programs provide continuity of funding, strengthen academic departments, and enhance graduate student and post-doctoral training. Third, industry/university cooperation improves job opportunities for graduates of the participating universities, at the same time enhancing the transfer of knowledge embodied in these graduates to industry. Thus, the opportunity to expand the research cooperation between industry and universities present a major challenge for the 1980's.

From our experience, several problems face universities, industry, and Government in the development of university/industry cooperative research. One is the possible restriction of information exchange on progress in research when dealing with proprietary issues of industry. Another concerns the ownership of patents and the nature of licensing agreements. The foundation is experimenting with and evaluating various modes of industry/university interactions to better understand these concerns.

In the near term, our experience has been that issues such as academic freedom, publications, and patents can be dealt with through open discussion between industry and the university and do not require Government action or intervention. There is a great deal of discussion and concern about these issues as relationships are being established, but they tend to diminish once the research begins. While the issues are important, the industry-university partners seem to be able to accommodate the interest of each in a way which contributes to the public good.

We have an active program of productivity improvement research to assess each of our operational programs. Thus, we will be able to suggest what kinds of relationships seem to work and why. This knowledge is made available to the funders of the research and to potential university and industry participants in these relationships.

II. SMALL BUSINESS INNOVATION RESEARCH PROGRAM

Small high technology firms represent an important national resource to the United States. Not only do they have strong research capabilities but they represent one of the best mechanisms to convert research into technology. Such firms accelerate technology innovation and can increase the commercial applications of NSE research for its potential economic and social benefits to the Nation.

At NSF, the small business innovation research (SBIR) program started in fiscal year 1977 when Congress directed NSF, through its annual authorization act, to award 7½ percent (or $1 million) of Rann research funds to small business firms. The program has grown to a level of $5.5 million in fiscal year 1983 and will more than double again by fiscal year 1985 to a level of over $12 million which will be about 1 percent of the NSF research budget. This large increase is due to the legislative requirements of the Small Business Innovation Development Act of 1982 which prescribes SBIR funding levels which will reach a governmentwide total of about $500 million in 10 agencies by fiscal year 1987.

The objectives of the Small Business Innovation Development Act of 1982 are to: Stimulate Technology innovation; Use Small Business to meet Federal research and development needs; Foster and encourage participation by minority and disadvantaged persons in technological innovation; and increase private sector commercialization of innovations derived from Federal research and development.

SBIR provides an important opportunity for small science and technology-based firms to participate in NSF research. It enables small firms to propose longer term, higher risk creative ideas in NSF program areas that could only be pursued by them with outside support. NSF awards also have been valuable to many firms in their obtaining private investment, other R&D awards and working arrangements with universities, Government agencies and large companies.

The legislation calls for a program that is structured in three phases and is modeled after the NSF SBIR program. At NSF, Phase I supports research for 6 months for up to $35,000 on important scientific or engineering problems of interest to NSF. Phase II funds those projects found most promising after phase I for up to $200,000 for 1 to 2 years. Phase III is the product development phase to pursue and commercial applications from the Government R&D conducted in phases I and II. It is entirely funded with private capital, usually from a venture capital firm interested in investment or a large industrial company looking to license or purchase new technology.

The program design provides a stopping point to evalute projects after phase I to determine whether a large phase II investment should be made. This is in contrast to the normal funding of the full scope of a research project at one time of funding a large portion at one time. Stopping for evaluation after phase I results are known has received high marks from some who evaluate R&D policies and practices.

The program is extremely competitive with almost 4,000 proposals received and less than 500 awards made to date. Proposals have been received from all 50 States and awards have gone to firms in 36 States and the District of Columbia. Historically, only one out of eight proposals have been funded in phase I and only one out of two or three of these receive a phases II award.

Small high technology firms often have excellent research capabilities in industrially relevant areas and frequently in places where possible small markets may deter larger firms from investing. Advanced instrumentation research for scientific and industrial measurement is an example of this. Phase II awards this past year included a wide range of interests which may lead to new scientific or industrial instruments: Tomography; spectral correlators; ion microscopy; and laser-based photoacoustic measuring. Other instrumentation projects involved: Eddy current imaging; microanalysis methods; and ion implantation.

The academic community, for the most part, was not supportive of the small business research legislation last year. Since the passage of the SBID Act, however, our staff and I have been invited to attend and/or speak at numerous conferences sponsored by universities wanting to know how to make the connection with small businesses involved in research projects in this program.

About one-half of NSF SBIR awardees have affiliated with universities, mainly using university scientists and engineers as consultants, but occasionally involving subcontracts or the use of specialized university facilities. About 10 percent of the budgets of successful NSF phase I projects have been earmarked for such activities. Although this may not be representative over all of the agencies, a significant amount of the total SBIR funds may be spent at the Nation's colleges and universities.

NSF suggests that small businesses develop ties with universities in responding to the annual program solicitation. University researchers are often more familiar with the "state of the art," as well as having more experience in proposal writing. If a small business uses this capability, it should result in a better written, more creditable, and technically accurate proposal, and can significantly increase its potential for an aware. The level of effort required by a university researcher experienced in proposal preparation is not great. Involvement of a university researcher in the actual project can give the research plan increased stature and further enhance its chances for success. Although the amount that can be contracted out (limited to one-third of the total award) is not a very large amount in phase I, it can be considered as an investment that could assure a university researcher participation in a potentially larger phase II project.

Clearly, most of the university/industry interaction occurring in SBIR projects is in a consulting arrangement. Some projects have utilized the unique equipment available in universities, and a few have subcontracted research to the university. However, many small businesses have little or no contact with the university. Because of the advantages of unviersities in responding to the SBIR program, this is changing.

Since a small business has everything to gain and the effort required by a university researcher is relatively small, there seems to be good reason for cooperation between these two groups in preparing a proposal. With the congressionally mandated growth of small business R&D funding, the opportunities and importance of interaction with small business will increase. More projects with higher funding will be available from multiple Federal sources. In these projects, this type of university assistance to the small businesses can form a basis for regional developement. In fact, States are already in the process of developing programs in which the university will assist small business in their region to identify and respond to the programs initiated by the Small Business Innovation Development Act of 1982.

SBIR offers a unique mechanism to leverage NSF research in many different areas. In addition to those previously stated, SBIR Firms increasingly invite the authors of publications, who are often doing basic research, to be consultants in their project. This approach couples basic to applied research and may provide a practical way for more ideas to move from the university into applications and the economy, to introduce university scientists to high tech firms and to encourage joint research efforts.

Large firms leverage the NSF-funded SBIR research. They are very interested in the advanced high-risk research funded by SBIR. Follow-on funding commitments have been received from such firms as Sohio, Arco, Ford Aerospace, Fairchild, and many others to support phase III efforts. Some large firms see the SBIR program as a farm system to stimulate innovation in large firms through their licensing or acquisition of the technology generated by small firms. Venture capital firms also leverage SBIR research many times.

In the first two solicitations where both phase I and II have been completed, follow-on private funding, due directly or in part to SBIR, exceeds $50 million based on $10 million of NSF research support. These same small companies also show a 125 percent increase in employment, in part due to SBIR. More than one-half of 1982 phase II awardees obtained follow-on funding commitments for phase III.

Finally, SBIR leverages small business start ups which are important to the country; 45 percent of grantees had 10 or less employees when they submitted their phase I proposal and 13 percent of all awards have gone to minority-owned firms.

III. BUDGET DATA

In fiscal year 1984, a total of $16.6 million has been allocated for these programs: $7 million for cooperative research projects; $3 million for cooperative research centers; and $6.6 million for small business innovation research.

The funding history for the various program elements shows a relatively constant level of support. However, this can be misleading in the true impact of funds leveraged from other sources. The cooperative project program's real effort is almost three times the amount in the ISI budget.

The cooperative centers program leverages industrial resources at a level of four to five times the amount provided through the ISTI budget. Follow-on funding due directly or in part to SBIR support now exceeds $50 million primarily related to the first solicitation which has completed both phases I and II. Leverage in this program is about five times the NSF support provided.

Mr. Chairman, This concludes my prepared statement describing NSF small business R&D and industry/university cooperative research programs. I will be pleased *to respond to your questions.*

Senator HEFLIN. Our next witnesses will be a panel, Dr. Mark Money, vice chancellor for research park and corporate relations, Texas A&M University, College Station, Tex.; and Dr. Quentin W. Lindsey, the science and public policy adviser, Office of the Governor of Raleigh, N.C.

We are delighted to have you two gentlemen.

Dr. Money has spent some 12 years in Utah before going to Texas A&M, and put together quite a renowned research park there.

Dr. Lindsey has been greatly involved in the research triangle.

The testimony that you have prepared is excellent. We appreciate your presence here today, and we will go by alphabetical order and let you start off, Dr. Lindsey.

STATEMENTS OF DR. QUENTIN W. LINDSEY, SCIENCE AND PUBLIC POLICY ADVISER, OFFICE OF THE GOVERNOR, STATE OF NORTH CAROLINA; AND DR. MARK MONEY, VICE CHANCELLOR FOR RESEARCH PARK AND CORPORATE RELATIONS, TEXAS A&M UNIVERSITY SYSTEM

Dr. LINDSEY. Thank you, Mr. Chairman. I appreciate being invited to testify here today.

I will cover three points in my testimony: First, background about how the Research Triangle Park was created; second, a few conclusions that may be useful regarding our experience with the Research Triangle Park; and third, comment briefly upon S. 1286.

Former Governor Luther Hodges, 6 years after he took initial steps in 1955 to establish the Research Triangle in North Carolina, described it as "an idea that has produced a reality—the idea that the scientific brains and research talents of three institutions and their life of research in many fields could provide the background and stimulation of research for the benefit of the State and Nation. In a way, the Research Triangle is the marriage of North Carolina's ideals," Governor Hodges said, "for higher education and its hope for material progress."

For several years prior to 1955, a noted sociologist at the University of North Carolina at Chapel Hill, Dr. Howard W. Odum, had made repeated attempts to foster a research complex of some sort in association with the University of North Carolina at Chapel Hill, with Duke University in Durham, and with North Carolina State University at Raleigh. All three institutions are within a 15-mile radius of the center of a triangle formed by these institutions as points. In addition, over the period 1952 to 1955, a North Carolina developer, Romeo Guest, sought to promote the establishment of industrial laboratories and other forms of research and development within this triangle. But not until Hodges, as Governor, combined the support of the State government with academic and industrial interests did concrete action begin to take place.

Now, in 1983, the triangle consists of the three universities noted plus a 5,000-acre Research Triangle Park located in the center of the triangle. Within this park nearly 50 public and private research organizations now function, plus another 50 organizations providing hotel, travel, banking and other services and functions. More than 20,000 people work in this park each day, and the total payroll amounts to approximately a half a billion dollars per year.

The Research Triangle is now a great asset to the State of North Carolina. We have become known as a State committed to scientific research and the development of high technology industry. By placing considerable emphasis upon high technology industrial growth throughout North Carolina, Governor Hunt has taken advantage of this tremendous resource over the past 7 years. We have averaged nearly $2 billion in new investment in industrial plant and equipment each year. During most of the current recession, our unemployment level has been running about 2 percentage points below the national average. The park has enhanced our ability to soften the effects of national recession.

Governor Hodges provided the type of leadership that perhaps only State government can provide; namely, the organizational arrangements necessary to bring these divergent public and private interests together behind a common purpose.

He first appointed a Research Triangle Committee under the leadership of a private business leader, but with the presidents of the universities and other business interests as members. Dr. George L. Simpson, professor of sociology at the University of North Carolina in Chapel Hill, and to some extent a protege of Howard Odum, was appointed director of committee activity. This appointment was of considerable importance, for Dr. Simpson possessed those qualities of conviction, understanding and persuasion that enabled him to harmonize the differences of opinion held by educators, industrialists, local business interests, and others concerning the nature, ownership, and operating principles of the emerging vision of the Research Triangle.

Members of this committee, with the support and encouragement of Governor Hodges, were able to persuade private interests to contribute funds for the purchase of initial tracts of land near the center of the triangle, upon which research institutions and firms could locate. State and local government units agreed to develop road and water and sewer facilities. The property and associated facilities were given the name Research Triangle Park.

I served on the faculty of North Carolina State University during the period 1951 to 1961 and was somewhat familiar with the emergence of the Research Triangle as an overriding concept and as an emerging organizational structure.

In August 1961 my family and I left to serve 7 years in Asia with the Ford Foundation, returning in 1968. Before our departure there was still considerable doubt in the minds of many, within the universities and within the governmental and industrial circles, as to whether the Research Triangle Park and associated activities would really become a lasting, stable development. As I returned to the United States in 1968 and joined the faculty at the University of North Carolina in Chapel Hill, I began to ask whether the Research Triangle would succeed or not. Without exception, the answers were yes.

Now, with that background, let me attempt to deduce a few guidelines or principles which may be of use to you. I assume that there are those who desire to create something similar to our Research Triangle Park.

First, you will need a compelling idea or vision of what you want to do. I assume that in a general sense you are seeking here in Alabama and elsewhere to develop stronger working relationships among academic institutions, existing and potential industrial firms, financial institutions, State and local government agencies and so on, and I assume also that the purpose is to enhance economic activity and to improve the well-being of the people of the State or of the region.

Second, you need to create an appropriate initial organization composed of leaders who clearly have vested interests in the concept. The organization must be staffed by an individual or individuals with the understanding, persuasive ability, integrity, and commitment essential to draw people together behind what you propose to do. I can assure you that whatever you do, it will be a bumpy road. There will be periods of discouragement and even despair. But if you assess conditions realistically in the beginning, your initial vision and commitment will carry you through.

Third, it helps to have a dedicated, objective external influence. In North Carolina it was State government under the leadership of the Governor. The danger of leadership resting entirely with those institutions, individuals, and firms directly involved and/or affected is that misunderstanding and dissension may arise. Things may appear to be tilting in favor of this institution, that firm, or those particular individuals.

In our case, State government was sufficiently removed to be considered objective, and yet had sufficient stake in the success of the entire operation to be thoroughly committed, capable of arbitrating disputes, and able to maintain an even hand.

Finally, I urge you to take contemporary conditions into account in any undertaking such as this. Many States are now striving to make more effective use of scientific, engineering, and technological resources in creating more and better jobs through economic growth. Many States now know more about these processes than we did in 1955. Other nations, particularly Japan, have become highly proficient in such matters, and competition for international markets is severe. Starting as we did in 1955, we perhaps had the luxury of more time to make mistakes and overcome them than anyone is likely to have in the years ahead.

Moreover, today the Research Triangle alone is not enough to enable us to create more and better jobs through technological innovation, and to achieve the various economic and other goals we hold to be important in North Carolina.

Without going into detail, let me say simply that our board of science and technology in North Carolina—and the universities, State government agencies, and private firms to which it relates, are concerned today with far more than our Research Triangle Park.

Development of the park was and still is based upon a strategy of industrial recruitment. Most of the facilities within the park are branches of either a large corporate firm with headquarters elsewhere, or of a Federal agency. Our weakness is that we do not yet have the spinofff industrial growth emanating from research in the park, or from the triangle universities, such as that which you find along Route 128 in Massachusetts or in Silicon Valley in California.

We continue to recruit industries, to persuade corporate firms to locate their new research facilities in the park, and their new production plants somewhere in the State. The park is a real asset in doing both. We are also using results of research to help our traditional industries, such as textiles, modernize in order to remain competitive in international markets. But our real thrust now is to devise ways by which new small business firms can be created and existing firms expanded. We believe that more jobs can be created through small business development than by large plant recruitment. Our intent is to devise ways by which results of research done in the Research Triangle area can be utilized in spinoff industrial business growth throughout the State.

Therefore, anyone contemplating the creation of a research park should, in my judgment, conceptualize the entire operation carefully. It should be more than just an outstanding place to locate research facilities. The park should be, instead, an integral part of a comprehensive strategy of economic growth. Seed and venture capital requirements, incubator facilities, and other institutional requirements needed to stimulate small business development should be included in the overall plan.

Now, before ending my testimony, let me comment briefly on S. 1286, as requested. I find it necessary to consider this bill in relation to, first, our Reseach Triangle Park experience; second, the importance of a comprehensive strategy for economic growth and job creation; and third, the need to place more emphasis on small business development in relation to research pursuits.

My position is simply as follows:

First, Government leadership must perform the catalytic functions that bring universities, private organizations and Government agencies together to achieve the goals inherent in S. 1286. These functions can be initiated to some degree by universities or the private sector. But they are most effectively performed by enlightened Government leadership.

This leadership role, in the detail I have described for North Carolina, cannot be performed by the Federal Government nor by local government, in my opinion. It is best performed by State government through the leadership of the Governor, but with involvement and support from the major elements of the power structure of a State, particularly the universities, the private business sector, and local government.

Yet I see no reference to the role of State government in S. 1286. This is a serious deficiency and should be corrected. I do not contend that all funds should flow through State government, although perhaps some should. The changes you are seeking to achieve, however, require partnership relations among government, industry, research institutions, and people—woven together in an economic growth strategy—that cannot be achieved by any Federal agency through administrative control over funds and their uses. It can, however, be developed at the State level, and for regional purposes by consortia of States.

Third, although I place emphasis upon the role of State governments, let me quickly add that the role of the Federal Government is also critical through the financial support visualized by S. 1286. But the Federal Government cannot, in my judgment, simply purchase the results that you want to achieve through appropriation of funds.

Neither can you set up a Federal agency to function in lieu of the role of State governments. As I see it, the Federal role is similar to that which we face at the State level as we work with local governments, private firms, and universities.

We are most effective in North Carolina in fostering the desired forms of economic growth when our modus operandi is catalytic and supportive rather than administrative and regulatory. You are providing for the supportive aspects in your proposed appropriation of funds. But I see no reference to the process by which a broad Federal strategy is to be devised that will guide the work of the Department of Commerce in administering this act, other than the advisory committee.

I do not believe that an advisory committee to the Secretary of Commerce will be sufficient to provide adequate guidance, nor do I believe that staff of any one department, unless functioning as a part of an interagency program that provides for effective interaction with other components of the Federal Government, will be capable of formulating the necessary guidance. Moreover, consideration of the appropriate linkages between Federal Government and State and local governments is omitted from consideration of committee membership and functions.

And finally, let me close with one point that I believe is relevant to us all. I wish anyone in Alabama and elsewhere complete success in research park development. We have in this Nation several unique opportunities for complementarity among States and regions. In any society there will always be degrees of competition and opportunities for cooperation. The future of the United States lies, in my judgment, in a preponderance of interstate and interregional cooperation rather than competition. International competition will be tough enough. To compound it with excessive interregional competition will be to the detriment of us all.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF DR. QUENTIN W. LINDSEY, SCIENCE AND PUBLIC ADVISER, OFFICE OF THE GOVERNOR, STATE OF NORTH CAROLINA

I. ESTABLISHING THE RESEARCH TRIANGLE PARK

Former Governor Luther Hodges, six years after he took initial steps in 1955 to establish the Research Triangle in North Carolina, described it as "an idea that has produced a reality—the idea that the scientific brains and research talents of . . . three institutions, and their life of research in many fields, could provide the background and stimulation of research for the benefit of the state and nation. In a way, the Research Triangle is the marriage of North Carolina's ideals for higher education and its hope for material progress.[1]

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[1] Quoted from "Luther H. Hodges, Businessman in the Statehouse: Six Years as Governor of North Carolina" (Chapel Hill, 1962), pp. 203-23, as quoted by Louis R. Wilson in the "The Research Triangle of North Carolina," (Chapel Hill: The Colonial Press, 1967) p. 1.

For several years prior to 1955, a noted sociologist at the University of North Carolina at Chapel Hill, Dr. Howard W. Odum, had made repeated attempts to foster a research complex of some sort in association with the University at Chapel Hill, with Duke University in Durham, and with North Carolina State University at Raleigh. All three institutions are within a 15-mile radius of the center of a triangle formed by these institutions as points. In addition, over the period 1952-1955, a North Carolina developer, Romeo Guest, sought to promote the establishment of industrial laboratories and other forms of research and development within this triangle. But not until Hodges, as Governor, combined the support of state government with academic and industrial interests did concrete action begin to take place.

Now, in 1983, the Triangle consists of the three universities noted plus a 5,000 acre Research Triangie Park located in the center of the Triangle. Within this Park nearly 50 public and private research organizations now function, plus another 50 organizations providing hotel, travel, banking and other services and other services and functions. More than 20,000 people work in this Park each day and the total payroll amounts to approximately a half billion dollars per year.

The Research Triangle is now a great asset to the State of North Carolina. We have become known as a state committed to scientific research and the development of high technology industry. By placing considerable emphasis upon high technology industrial growth throughout North Carolina, Governor Hunt has taken advantage of this tremendous resource over the past seven years. We have averaged nearly $2 billion in new investment in industrial plant and equipment each year. During most of the current recession, our unemployment level has been running about two percentage points below the national average. Unemployment is determined by many factors. But since we have been traditionally a low income state, clearly the existence of the Research Triangle has made it possible for us to link science and technology with other economic development pursuits across the state. This has enhanced our ability to soften the effect of nationwide recessions.

II. THE ESTABLISHMENT STRUGGLE

The fact that different people began to formulate, in different ways and for different reasons, the concept that later became identified as the Research Triangle, illustrates both the potential of what now exists as well as the difficulty in creating it.

The three existing universities—Duke, Carolina and State—represented great assets in close proximity, but each is a different type of university and two are public and one is private. The regional airport—Raleigh-Durham—existed in nearly the center of the Triangle but the remainder of the area was still farm and forest land with no water and sewer facilities, no streets or other requirements that must exist if physical facilities are to be concentrated in a particular area. And whereas the universities, private interests and others were in general supportive of the desire to create something, diverging views existed as to precisely what should be created and how it should be accomplished.

Governor Hodges provided the type of leadership that perhaps only state government can provide, namely, the organizational arrangements necessary to bring these divergent public and private interests together behind a common purpose. He first appointed a Research Triangle Committee under the leadership of a private business leader, but with the presidents of the universities and other business interests as members. Dr. George L. Simpson, Professor of Sociology at the University of North Carolina is Chapel Hill, and to some extent a protege of Howard Odum, was appointed Director of Committee activity. This appointment was of considerable importance, for Dr. Simpson possessed those qualities of conviction, understanding and persuasion that enabled him to harmonize the differences of opinion held by educators, industrialists, local business interests and others concerning the nature, ownership and operating principles of the emerging vision of the Research Triangle.

Members of this committee, with the support and encouragement of Governor Hodges, were able to persuade private interests to contribute funds for the purchase of initial tracts of land near the center of the Triangle upon which research institutions and firms could locate. State and local government units agreed to develop roads and water and sewer facilities. The property and associated facilities were given the name "Research Triangle Park" and, with later additions, the area now totals more than 5,000 acres.

By 1960 the key organizational arrangements had been created. First, the initial Research Triangle Committee was transformed to become a nonprofit corporation entitled the Research Triangle Foundation. It was given the responsibility of managing the Park. This included guiding the development of roads and water and sewer facilities, developing criteria for determining the types of research organizations sought for the Park, and sale of land to tenants who proposed to operate within the Park. Second, the Research Triangle Institute was established in 1958 as a not-for-profit organization wholly owned by the consolidated University of North Carolina and by Duke University, but operated in close proximity to, or in conjunction with, the research facilities of the three Research Triangle universities. Third, the Research Triangle Commission was established to provide guidance to the counties and municipalities within close proximity to the Research Triangle Park, anticipating that growth of the Park would have a substantial effect over time upon these local government units. This Commission later became a Regional Council of Governments.

I served on the faculty of North Carolina State University during the period 1951–61 and was somewhat familiar with the emergence of the Research Triangle as an overriding concept and as an emerging organizational structure. In August, 1961, my family and I left to serve seven years in Asia with the Ford Foundation, returning in 1968. Before our departure there was still considerable doubt in the minds of many, within the universities and within governmental and industrial circles, as to whether the Research Triangle Park and associated activities would really become a stable lasting development. The recession in 1957 had dimmed the hopes of many; some industrial firms who had previously planned to locate facilities in the Park cancelled such arrangements. Much debate had occurred with respect to whether Park facilities should be managed as a profit-making operation or a not-for-profit entity. The question of whether universities would fully cooperate with the emerging Research Triangle Institute was debated: Would another research institution simply duplicate and/or compete with university research? Would the Institute become another competitor for the same funds? Would associated competition for funds prevent the Institute from playing a meaningful unifying role? Universities, by tradition and throughout the country, are frequent competitors on athletic fields as well as in the pursuit of research funds. In short, all the usual reasons why great ideas fail to materialize as expected were present.

As I returned to the U.S. in 1968 and joined the faculty at the University of North Carolina in Chapel Hill in September, I began to inquire of leaders within the universities and within the Park as to whether the Research Triangle would succeed or not. Without exception, the answers were positive. All were convinced that the concept was destined to succeed. Several additional facilities had been established in the Park, including IBM which is the larger single unit, the National Institute for Environmental Health Sciences, and many others. The number and diversity continue to increase each year. In addition, the Research Triangle Institute has become a self-supporting contract research organization and is looked upon as another institutional asset by the universities and others within the Triangle.

III. WHAT DOES IT TAKE TO SUCCEED?

Given this brief sketch of what the Research Triangle is and how it has developed, let me attempt now to deduce a few guidelines or principles that may be of use to you. I assume that there are those among you who desire to create something similar to our Research Triangle Park.

1. Compelling idea or vision.—First, you will need a compelling idea or vision of what you want to do. I assume that, in a general sense, you are seeking to develop stronger working relations among academic institutions, existing and potential industrial firms, financial institutions, state and local government agencies and so on, in Alabama and elsewhere. I assume also that the purpose is to enhance economic activity and improve the well-being of the people of a state or region. We have had such notions, expressed in various ways, throughout the history of the Research Triangle. But our vision of what should be created, including the name that emerged, coincided rather well with our conditions: Three universities in close proximity and willing to cooperate, a supporting state government, strong interest and commitment by the private sector, and a realization that we needed to take what then appears to be drastic steps to improve conditions in North Carolina. In addition, the vision that was put forward became appropriate enough, compelling enough and comprehensive enough to enable those who thought it would and should succeed to overcome the arguments of those who thought it could not, or that thought things should be done some other way.

2. Organization and leadership.—Second, you need to create an appropriate initial organization composed of leaders who clearly have vested interests in the concept. The organization must be staffed by an individual or individuals with the understanding, persuasive ability, integrity and commitment essential to draw people together behind what you propose to do. The organization, and the characteristics of the entrie activity, will likely evolve as the details of what you are seeking to do become clear, just as occurred in North Carolina. I can assure you that, whatever you do, it will be a bumpy road. There will be periods of discouragement and even dispair. But if you assess conditions realistically in the beginning, your initial vision and commitment will carry you through.

3. *External objective influence.*—Third, it helps to have a dedicated, objective external influence. In North Carolina it was state government under the leadership of the Governor. The danger of leadership resting entirely with those institutions, individuals and firms directly involved and/or affected, is that misunderstanding and dissension may arise. Things may appear to be tilting in favor of this institution, that firm or those particular individuals. In our case, state government was sufficiently removed to be considered objective, and yet had sufficient stake in the success of the entire operation to be throughly committed, capable of arbitrating disputes, and able to maintain an even hand.

IV. TAKE CONTEMPORARY CONDITIONS INTO ACCOUNT

Finally, I urge you to take contemporary conditions into account. Many states now are striving to make more effective use of scientific, engineering and technological resources in creating more and better jobs through economic growth. Many states now know more about these processes than we did in 1955. Other nations, particularly Japan, have become highly proficient in such matters and competition for international markets is severe. Starting as we did in 1955, we perhaps had the luxury of more time to make mistakes and overcome them than you are likely to have in the years ahead. Moreover, several program components in addition to what I have described as the Research Triangle are essential if states are to realize their economic, social and political potential in today's world.

Requirements in addition to the park

Today, the Research Triangle alone is not enough to enable us to create more and better jobs through technological innovation, and to achieve the various economic and other goals we hold to be important in North Carolna. Additional organizational arrangements and specific initiatives are required.

Central to our total program is the North Carolina Board of Science and Technology. The Governor chairs this 15-member Board, I serve as the Executive Director by virtue of my role as the Governor's Science and Public Policy Advisor. The remaining members are primarily scientists from academia and industry, plus one representative each from state and local government.

The scope of "science," as now defined by the Board, includes economic, social and behavioral sciences, as well as physical and biological sciences, engineering and mathematics. The issues we address range from straight forward "hard science" analyses, such as how to recover a valuable chemical from the waste accumulated by an industrial plant, to policy studies or planning exercises such as defining the steps to take to improve science and mathematics instruction in all of our elementary and secondary schools. We do not shy away from basic or fundamental scientific exploration if such are required. Neither do we limit ourselves to such pursuits. Instead, we seek to ensure that the scientific, engineering and technological resources of North Carolina are used in ways that benefit the people of the state and nation in both the short and long-run.

In a very general sense, the goal or purpose of the Board of Science and Technology is to serve as a "nerve center" between state government and public and private research institutions, firms and agencies, including local governments. It is the catalyst by which we are striving to develop strong and useful working relationships among government, academia, industry and the general public, particularly in relation to science and technology matters. As Governor Hund has stated, "we believe that the center of gravity for technological innovation, on matters other than defense and space, must shift from the federal to the state level," and this Board is the key unit by which the strategies essential to this shift may be devised in North Carolina.

Know what is needed today

Without going into detail, let me simply point out that our Board of Science and Technology—and the universities, agencies of state government and private firms to which it relates—are concerned today with far more than our Research Triangle Park. The goals are similar to those of nearly 30 years ago: we remain a relatively poor state, we need to create more and better jobs for our people, and we need to preserve the quality of our environment. In short, we are still striving to make use of the results of scientific and engineering research to improve conditions for our people through economic growth.

Development of the Research Triangle Park, however, was and still is based upon a strategy of industrial recruitment. Most of the facilities within the Park are branches of either a large corporate firm with headquarters elsewhere, or of a federal agency. We do not have the spinoff industrial growth emanating from research in the Part or from the Triangle universities that you find along Route 128 in Massachusetts or in Silicon Valley in California.

We continue to recruit industries, to persuade corporate firms to locate their new research facilities in the Park and their new production plants somewhere in the state. The Park is a real asset in doing both. We are also using results of research to help our traditional industries, such as textiles, modernize in order to remain competitive in international markets. But our real thrust now is to devise ways by which new small business firms can be created and existing firms expanded. We believe that more jobs can be created through small business development than by large plant recruitment. We think that small business growth will also enhance community development throughout the state. Moreover, research expenditures by firms and agencies in the Park, and by our public and private universities, total more than $500 million per year. Our intent is to devise ways by which results of this research can be utilized in spinoff business growth in the state.

Therefore, anyone contemplating the creation of a research park should conceptualize the entire operation carefully. In my judgment it should be more than just an outstanding place to locate another research facility. The park should be, instead, an integral part of a comprehensive stratety of economic growth. Seed and venture capital requirements, incubator facilities and other institutional requirements needed to stimulate small business development should be included in the overall plan.

Comments on S. 1286

Before ending my testimony, let me comment briefly on S. 1286, as requested. I find it necessary to consider this bill in relation to our research park experience, the importance of a comprehensive strategy for economic growth and job creation, and the need to place more emphasis upon small business development in relation to research pursuits. My position is simply as follows:

1. Government leadership must perform the catalytic functions that bring universities, private and organizations, and government agencies together to achieve the goals inherent in S. 1286. These functions can be initiated to some degree by universities or by the private sector. But they are most effectively performed by enlightened government leadership.

2. This leadership role, and the detail I have described for North Carolina, cannot be performed by the federal government nor by local government. It is best performed by state government, through the leadership of the Governor, but with involvement and support from the major elements of the power structure of a state. Yet I see no reference to the role of state government in S. 1286. This is a serious deficiency and should be corrected. I do not contend that all funds should flow through state government, although perhaps some should. The changes you are seeking to achieve, however, require partnership relations among government, industry, research institutions and people, woven together in an economic growth strategy, that cannot be achieved by any federal agency through administrative control over funds and their uses. It can, however, be developed at the state level, and for regional purposes by consortia of states.

3. Although I place emphasis upon the role of state governments, let me quickly add that the role of the federal government is also critical through the financial support visualized by S. 1286. But the federal government cannot, in my judgment, simply purchase the results you want to achieve through appropriation of funds. Neither can you set up a federal agency to function in lieu of the role of state governments. As I see it, the federal role is similar to that of each state as we work with local governments, private firms and universities. We are most effective in North Carolina in fostering the desired forms of economic growth when our modus operandi is catalytic and supportive rather than administrative and regulatory. You are providing for the supportive aspect in your proposed appropriation of funds. But I see no reference to the process by which a broad federal strategy is to be devised that will guide the work of the Department of Commerce in administering this act other than the Advisory Committee. I do not believe that an Advisory Committee to the Secretary of Commerce will be sufficient to provide adequate guidance. Nor do I believe that staff of any one department, unless functioning as a part of an interagency program that provides for effective interaction with other components of the

federal government, will be capable of formulating in the necessary guidance. Moreover, consideration of the appropriate linkages between federal government and state and local governments is omitted from consideration of committee membership and functions.

Regional complementarity

Let me close with one final point that I believe is relevant to us all. I wish anyone in Alabama and elsewhere complete success in research park development. We have in this nation several unique opportunities for complementarity among states and among regions. In any society, there will always be degrees of competition and opportunities for cooperation. The future of the United States lies, in my judgment, in a preponderance of interstate and interregional cooperation, rather than competition. International competition will be tough enough. To compound it with excessive interregional competition will be to the determent of us all.

Senator HEFLIN. Dr. Money.

Dr. MONEY. Thank you, Mr. Chairman. I appreciate the opportunity of being invited to testify at this hearing in support of an increased effort for research and development activities in the Nation. However, my specific testimony will address the role of research parks in stimulating technological innovations and economic growth.

A little background might be helpful. I have been involved with the university-related research park phenomenon for the past 15 years; and my current position as vice chancellor for Research Park and corporate relations of the Texas A&M University system affords me the opportunity to establish a research park there. Prior to this I was executive director for the University of Utah Research Park for 13 years. My doctoral dissertation, completed in 1970, was entitled "A Model for the Establishment of a University-Related Research Park within a Framework of Selected Management Principles.

It was my great opportunity at that time to visit the Research Triangle in North Carolina. It literally became an inspiration to us in our development, but I think the highlight of my experience in that was the opportunity to visit with Luther Hodges for several hours. He was most gracious and shared with me the history of the park and many ideas and concepts.

Let me say that I fully agree with Dr. Lindsey in his final remarks concerning the cooperation that can prevail between the research parks and research organizations in various parts of the country. As Luther Hodges was very gracious to me and shared the background and information, I have had the opportunity to consult with a number of universities and government entities throughout the United States and Canada, and in fact, overseas as they have investigated the possibility of establishing research parks. And I have never felt that we were in competition with one another directly.

I do not feel that Governor Hodges felt that, certainly at that time, Utah was any threat to North Carolina. We have never felt in Utah that those with whom I have consulted were going to take companies that might eventually locate in our research park and go to another area, and so I think we have this common goal of helping each other in our regional economic development as we combine our efforts to counteract the threat of the international competition.

While there has been a long history of cooperative research projects between university and private enterprises, the concept of a research center in the private sector being placed on land made available by a university is a fairly recent phenomenon. It is one that is accelerating rapidly, however. In fact, university-related research parks are emerging, I would think, as a growth industry of the 1980's. Since the pioneering contributions of the Stanford Industrial Park in 1951 and the Research Triangle near the major universities in North Carolina in the late 1950's, there have been research and development parks established with university affiliations at Utah, and it has been mentioned, Renssaelaer Polytechnic Institute in Troy, N.Y., Purdue, Arizona State, Michigan, South Carolina, Central Florida University in Orlando, Washington State, Delaware, New Mexico, Kansas, and the list goes on.

The impetus for this growth it seems to me is the acknowledged benefits to both the university and the private industry in this relationship. Industry benefits from an attractive site in a controlled environment near the university, and certainly both Stanford and the Research Triangle, the acknowledged superstars in the industry, have that beautifully controlled environment, the one we attempted to emulate in Utah, and will do in Texas. But also, the fact that students and graduates are avaialable for employment, and that industry can use specialized equipment located at the university on a time available and cost recovery basis.

They also have access to the university's information retrieval resources. Employees are able to attend the athletic and cultural events on campus, the industrial research specialists have the possibility of adjunct faculty appointments. Continuing education and training opportunities for employees are possible through special classes and seminars made available by the academic institutions.

Now, the university benefits in a number of ways: First, from the return on the investment in the land used by the research park, and by the way, this was the initial motivation for Stanford's industrial park, the fact that they had acreage of land there that was being taxed by the city of Palo Alto and they needed to get a return on investment on it in their private university activity.

Faculty members have opportunities for consulting near the university, and there is the possibility of joint research projects with industry. Employment opportunities for students and graduates are increased, and the university's image is enhanced in these research-related resources that are available.

The university development programs may receive contributions of specialized equipment from park occupants, and the area's overall economic evelopment is aided by technological innovation and the jobs created by spinoff companies which may be formed. And so it is in this role of research parks in stimulating the technological innovation and economic growth that I have been asked to address you here at this hearing.

While at the University of Utah, the 320-acre research park was developed from a military rifle range to a site which now accommodates 17 buildings, about 28 companies in private and governmental sectors, with 3,000 employees on about one-third of the available land that is available. A brief history of just two of these companies will serve to illustrate how research parks can serve to promote university-industry interaction to foster economic development.

The first private company in the research park was a firm called Terra Tek. It was a small firm. It was started by Dr. Wayne S. Brown, former head of the mechanical engineering department and on the faculty of the University of Utah. He had the involvement of the dean of engineering, and also an industry colleague in the geology department at the Massachusetts Institute of Technology. And with just two full-time employees this company started in research work in the field of rock mechanics, or the study of certain rock formations under extreme pressures.

This work was extended to the extensive testing of other materials, and the company's structure expanded to include a drilling research laboratory which had the very unique idea of taking a 16-inch gun barrel from an old World War I battleship and milling out the center, placing it vertically into the ground, and there under the simulated pressures and temperatures encountered in drilling at depths of up to 30,000 feet, they can then test the drill bits or the drilling equipment. And they have there, I think, what is unique in the world, is the drilling test laboratory, once again, from the innovation of the research at the university.

From this work a company, a subsidiary, was established to test and evaluate core samples from drilling and energy companies, and while investigating the feasibility of using geothermal energy for the heating of greenhouses, another subsidiary was started to propagate native plants to aid in the environmental work of replanting, and reforestation, and strip mining, and cutting out for pipelines, or highways, and freeways. In all of these efforts close cooperation between the company and the university continued. Faculty consultants were used in specialized areas. Graduate students were hired on a part time basis and later given full-time positions as they were graduated. The library system was used for information retrieval, and specialized equipment such as scanning electron microscopes and ceramic furnaces in the departments were used on a time available and a cost basis.

Now, the economic consequences of this small company, of the university-industry cooperation have resulted in a family of companies which has grown from two full-time employees at a barely break-even operation in 1970 to 450 employees producing essentially research-related services in excess of $15 million. In its early stages the company grew in excess of 40 percent a year. That growth has moderated now to 20 to 25 percent in recent years but is continuing strong.

Another success story that we have started in an old temporary World War II barracks on the campus, Dr. David C. Evans, head of computer science, in company with Prof. Ivan Sutherland of Harvard developed a unique process utilizing computer technology to produce high-resolution graphics which could be used in simulation of images with wide commercial applications in computer-aided design, computer-aided manufacturing from what we now commonly refer to as computer graphics.

Now, using the same elements of cooperation between the company and the university, this company has also grown from a core group of about 10 persons to over 800 employees housed in three separate buildings on the research park. In the early days this was really a struggle. I remember we leased or rented the space in the old temporary buildings for a very modest amount, just enough to cover out-of-pocket expenses, and to avoid the accusation of the public institution subsidizing the private sector, they would pay a modest amount of rent, and then admonish me to keep the check in the top drawer in case the auditors came around, but to hold it until they let me know. And we did that, and now the company has grown to over 800 employees, as I said. It is now highly profitable with gross revenues approximating $60 million a year, and an acknowledged leader in its field in computer graphics.

Now, while it may be true that these companies could have started and prospered in locations other than a university-related research park, officers in both companies rapidly acknowledge that the benefits of being near the university, and the cooperation, and interaction which took place were definite factors in the success of the companies. They are both excellent examples of the advice given me by the Honorable Luther Hodges, former Governor of North Carolina and Secretary of Commerce to President Kennedy, when I visited with him in relation to my dissertation research.

He admonished me that: "The best types of companies and the best types for industrial development are those which are home grown, using the talents and resources of the community, because in the business of industrial development." He said: "Those who live by the sword die by the sword; and those who pirate industries away from other States in time have them pirated by those who offer subsidized inducements." And this is one round after another and really benefits no one.

Also, the testimony given by Mr. Colton from NSF concerning the innovation centers, we find these to be compatible with the research-park concept. We have the innovation center at the University of Utah, and it is my understanding that 7 grants in the second stage out of the 100 or so were given to companies in the research park at the University of Utah. So that shows a tie between the university impetus to develop the research parks, and also the Government program to aid in the small business and technological innovation.

Now, the rapid growth of these parks has raised a question of whether there might be too many in relation to the availability of tenants or companies. As cited in the report of the General Accounting Office to which you referred, Mr. Chairman, a report prepared by Ohio State University in 1980 found that 27 university-related research parks have been started since 1951, and not all of these have succeeded, however. They found that of the 27 started, 6 had clearly succeeded, 16 had failed, and 5 were in between.

It seems to me in this world of uncertainty there is at least one thing certain, and that is in this day and age where so much attention is being given to the attraction of high-technology companies by every community, chamber of commerce, university-industrial research park and so on, there probably is not enough to satisfy the needs of all of those who are staking their economic salvation on high technology. But there is some evidence in recent literature, however, that research parks located near or in conjunction with universities who have special strengths in areas that are attractive to industry may have a distinct advantage in attracting technology related companies.

And another bit of excellent advice from Governor Hodges was that universities in starting these parks should be honest with industry, honest and acknowledge the areas in which they feel they have some expertise, but readily acknowledge those areas in which others perhaps have more to offer because the institution certainly cannot fool industry very often.

In a recent report prepared by the General Accounting Office, the one to which you referred of the Federal role in fostering university-industry cooperation, it was stated that research parks near universities with significant research programs over "the most dramatic contributions to innovation" and that payoffs to the participants are quite high. They do, however, in the conclusion of the report find that there is a greater chance of success if the following are present:

Well-defined objectives and expected outcomes of the collaborations; or in other words, a definite objective. The matching of the resources, needs and interests of both university and industrial partners; and institutional commitments and leadership capable of reconciling the generic differences between universities and industrial partners without incursions on the independence of either. And I am sure that in subsequent testimony here and in your deliberations in Huntsville tomorrow that will be amplified.

The report of the GAO is an excellent review of the entire subject of university-industry collaboration. Chapter 2 of that report entitled "The Research Park Approach" is especially pertinent to what I have reviewed with you today. It also deals with other institutional arrangements of cooperative research centers and industrial extension services. The report concludes generally that "the Federal Government has played a significant role in creating and sustaining each type of institutional arrangement by providing support of basic and applied research at universities to build excellence in fields of science at the frontiers of emerging industrial technology. It provides contract support for R&D at new spinoff high technology firms, provides seed money to stimulate creation of cooperative R&D centers plus continuing project support by grants and contracts, and both seed money and continued funding of extension services."

Now, with respect to S. 1286, may I first say that I received the bill only recently and have not had a chance to study it extensively. However, it would be my opinion that this legislation to establish a program to conduct research and development for improved manufacturing technologies would materially assist the economic development of this country, and without going into the mechanisms by which it is purported to be accomplished, the programs of grants and cooperative agreements seems to me would give incentive to organizations to engage in research on methods of producing more efficient manufacturing processes and methods which may not otherwise be able to expend funds without the immediate prospect of a return on investment.

Now, I am sure all of us are aware and deeply concerned with that big black cloud on the horizon, the deficit, and are very wary of more government appropriations and more bills that require the expenditure of the national resources. However, it seems to me that if those programs are those of industrial development and economic development which in turn have a payoff and generate money and generate taxes to replenish the national treasury, that those are appropriate.

So those that then have to have some immediate prospects of return on investment would, I think, welcome this, and this is especially true of universities, colleges, and research organizations which have knowledge and expertise in areas which could contribute to technological innovations if grants and cooperative agreements as provided in the proposed legislation were made available.

Thank you, Senator.

[The statement follows:]

STATEMENT OF DR. MARK L. MONEY, VICE CHANCELLOR FOR RESEARCH PARK AND CORPORATE RELATIONS, TEXAS A&M UNIVERSITY SYSTEM

Mr. Chairman, members of the committee, I appreciate the opportunity to testify at this hearing in support of an increased effort for research and development activities in the nation. My specific testimony will address the role of research parks in stimulating technological innovations and economic growth.

The following background information may be helpful. I have been involved in the university-related research park phenomenon for the past fifteen years. My current position is Vice Chancellor for Research Park and Corporate Relations at The Texas A&M University System. Prior to this I was Executive Director of the University of Utah Research Park for thirteen years. My doctoral dissertation completed in 1970 was entitled "A Model for the Establishment of a University-Related Research Park Within a Framework of Selected Management Principles". It has been a stimulating experience to serve as a consultant to a number of universities and governmental entities throughout the United States and Canada as they have investigated the possibility of establishing research parks.

While there has been a long history of cooperative research projects between universities and private enterprises, the concept of a research center from the private sector being placed on land made available by a university is a fairly recent development that is accelerating rapidly. In fact, university-related research parks are emerging as a growth industry of the 1980's. Since the pioneering contributions of the Stanford Industrial Park in 1951 and the Research Triangle near the major universities in North Carolina in 1960 there have been research and development parks established with university affiliations at Utah, Renssaelaer Polytechnic Institute in Troy, New York, Purdue, Arizona State, Michigan, South Carolina, Central Florida University in Orlando, Washington State, Delaware, New Mexico, Kansas, Princeton, New Jersey, Missouri, Georgia, Illinois, Colorado, Texas, Connecticut, Nevada, and the list goes on.

The impetus for this growth is the acknowledged benefits to both the university and private industry. Industry benefits from an attractive site in a controlled environment near the university, and from the fact that students and graduates are available for employment. In addition, industry can use specialized equipment located at the university on a time available and cost recovery basis. They also have access to the university's information retrieval resources. Employees are able to attend the athletic and cultural events on the campus, and industrial research specialists have the possibility of adjunct faculty appointments. Continuing education and training opportunities for employees are possible through special classes and seminars.

The university benefits from the return on investment in the land used by the research park. Faculty members have opportunities for consulting near the university, and there is the possibility of joint research projects with industry. Employment opportunities for students and graduates are increased, and the university's image is enhanced in research-related resources. University development programs may receive contributions of specialized equipment from park occupants, and the area's overall economic development is aided by technological innovation and the jobs generated by "spin off" companies. It is this role of research parks in stimulating technogical innovation and economic growth that I have asked to address.

While at the University of Utah, the 320 acre research park was developed from a military rifle range to a site accommodating seventeen buildings, twenty eight technology related companies with 3,000 employees on about one-third of the available land. A brief history of just two of these companies will serve to illustrate how research parks can serve to promote university-industry interaction to foster economic development.

The first private company in the research park was a firm called Terra Tek. It was started by Dr. Wayne S. Brown, former Head of the Mechanical Engineering Department of the University of Utah, with involvement by the Dean of Engineering and an industry colleague in the Geology Department of the Massachusetts Institute of Technology (MIT). With two full-time employees this company started in research work in the field of rock mechanics or the study of certain rock formations under extreme pressures. This work was extended to the extensive testing of other materials. The company structure expanded to include a drilling research laboratory which utilized the sixteen inch gun barrel from a World War II battleship placed vertically in the earth to simulate the pressure and temperature encountered in drilling at depths of up to thirty thousand feet.

From this work a company subsidiary was established to test and evaluate core samples from drilling and energy companies. While investigating the feasibility of using geothermal energy for the heating of greenhouses another subsidiary was started to propogate native plants to aid in the environmental work of replanting and reforestation. In all of these efforts close cooperation between the company and university continued. Faculty consultants were used in specialized areas. Graduate students were hired on a part-time basis and later given full-time positions when they were graduated. The library system was used for information retrieval and specialized equipment such as scanning electron microscopes and ceramic furnaces in the departments were used on a time available and cost recovery basis.

The economic consequences of this university-industry cooperation have resulted in a family of companies which has grown from two full-time employees in a barely break-even operation in 1970 to 450 employees producing essentially research-related services in excess of $15 million. In its early stages the company grew in excess of 40% a year. That growth has moderated to 20–25% in recent years but is continuing strong.

Another company starting in temporary World War II barracks on the campus was the Evans and Sutherland Computer Company. Dr. David C. Evans was Head of the Computer Science Department at the University of Utah. He and Dr. Ivan Sutherland of Harvard developed a unique process utilizing computer technology to produce high resolution graphics which could be used in simulation of images with wide commercial applications in computer aided design and computer aided manufacturing. Using the same elements of cooperation between the company and the university this company has grown from a core group of about ten persons to over 800 employees housed in three separate buildings on the research park. Experiencing losses in the early years, the company has grown rapidly and is now highly profitable with gross revenues approximating $60 million per year.

While it may be true that these companies could have started and prospered in locations other than a university-related research park, officers in both companies readily acknowledge the benefits of being near the university and the cooperation and interaction which took place as definite factors in the success of the companies. They are both excellent examples of the advice given me by The Honorable Luther Hodges, former Governor of North Carolina and Secretary of Commerce to President Kennedy, when I visited with him in relation to my dissertation research. He said, "The best type of companies to develop are those which are home grown, using the talents and resources of the community. In the business of industrial development, those who 'live by the sword, die by the sword.' Those who pirate industries away from other states, in time have them pirated by those who offer subsidized inducements. This benefits no one."

The rapid growth of these parks has raised a question of whether there might be too many in relation to the availability of tenants. A report prepared by Ohio State University in 1980 found that twenty-seven university-related research parks have been started since 1951. Not all of these have succeeded however. The report found that of the twenty-seven, six had clearly succeeded, sixteen had failed, and five were "in-between". There will probably not be enough "high tech" industry to satisfy all the industrial development projects attempting to attract such companies. There is evidence in the recent literature, however, that research parks located near or in conjunction with universities may have a distinct advantage in attracting technology-related companies. In a recent report prepared by the General Accounting Office (GAO) on the federal role in fostering university-industry cooperation, it was stated that research parks near universities with significant research programs offer "the most dramatic contributions to innovation" and that payoffs to the participants are quite high. The conclusion of the report finds that there is a greater chance of success if the following are present: Well-defined objectives and expected outcomes of the collaborations; a matching of the resources, needs, and interests of both university and industrial partners; and institutional commitments and leadership capable of reconciling the generic differences between universities and industrial partners without incursions on the independence of either:[1]

The report by the U.S. General Accounting Office is an excellent review of this entire subject of university-industry collaboration. Chapter two of that report entitled "The Research Park Approach" is especially pertinent to what I have reviewed with you today. It also deals with other institutional arrangements of cooperative research centers and industrial extension services. This report concluded that:

"The federal government has played a significant role in creating and substaining each type of institutional arrangement by providing: Support of basic and applied research at universities to build excellence in fields of science at the frontiers of emerging industrial technology; Contract support for R&D at new spin-off high technology firms; Seed money to stimulate creation of cooperative R&D centers plus continuing project support by grants and contracts; and Both seed money and continued funding of extension services."[2]

With respect to S. 1286, it would be my opinion that this legislation to establish a program to conduct research and development for improved manufacturing technologies would materially assist the economic development of this country. The programs of grants and cooperative agreements would give incentives to organizations to engage in research on methods of producing more efficient manufacturing processes and methods which may not otherwise be able to expend funds without the immediate prospects of a return on investment. This is especially true of universities, colleges and research organizations which have knowledge and expertise in areas which could contribute to technological innovations if grants and cooperative agreements as provided in the proposed legislation were made available.

Thank you.

Senator HEFLIN. Thank you, gentlemen. I think your testimony is excellent, and we appreciate very much your coming and being here and giving us the benefit of your advice.

I notice, Dr. Money, that we have a Texas A&M Research Park brochure here. You have some with you. Maybe we will take a break after a while and maybe some people might like to pick up copies as well as copies of the testimony. We appreciate very much your testifying.

Now, you mentioned special strengths, and here in the Birmingham area you have special strengths. In industry you have the headquarters for the southeast of the power utility. You have Southern Services Co. which is the research arm of the power utility. They have done a lot of work on nuclear power in the past. It seems that that maybe now is coming to a halt, and maybe there are changes approaching, but they do various research in that regard.

We have one of the best medical centers in the Nation that has developed here, and one of the best dental schools. And not too distant from here is Marshall Space Flight Center, and one of the tasks, assigned tasks of Marshall Space Flight Center is material processing in space. And today, each day we turn on the television and we read in the newspaper what is occurring on the flight of the shuttle and spacelab. And we know that some businesses like Johnson & Johnson and McDonnell-Douglas have already committed large sums of money dealing with the processing of drugs, pharmaceuticals in space which are medically related.

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[1] Report by the General Accounting Office, "The Federal Role in Fostering University-Industry Cooperation," 83-22, May 22, 1983.

[2] Ibid., p. 52.

It seems to me that by coincidence that this is an area that on a long-term basis, not immediate, that should be explored.

You have two strengths here, a medical center, and you have a strength in Huntsville which has the responsibility dealing with the commercialization of materials processing in space, largely where the advantage is of zero gravity. This is something I think that we want to look into as well as other matters.

We have had here in Alabama for a long time Southern Research Institute which has done a variety of things. Right now they are rather eminently involved in cancer research as well as others, but it is an outgrowth really of the private sector and availability of funding over a long period of time.

So in addition to that here in Birmingham, we have the headquarters of a number of engineering concerns, and we have strong engineering schools at the University in Birmingham, University in Tuscaloosa, Auburn University, and the University in Huntsville. Huntsville, of course, has been primarily involved in the engineering and space. They have adjunct professors who are scientists. They brought in Dr. Werner Von Braun, the German scientist. In effect, you have a very effective research park in Huntsville for a number of years dealing with space matters.

So I am just reciting this sort of thing which goes along with the statements you made. You have got certain special strengths, and you ought to consider these special strengths, and maybe there are others that I have not mentioned. I do not mean to be all-inclusive. You always make a mistake when sometimes you get specific, because you omit somebody or omit some institution, and it is not the intent to do that.

Have you observed, though, that in the initial beginning of the cooperative efforts between university and industry in the research parks that they have dealt with the special strengths of the universities and the specific needs of industry?

Mr. MONEY. Yes, Senator, but let me say that we are not always wise enough to know exactly what they are and what will appeal to industry. We know, for exmple, that the electrical engineering department and the subsequent developments in electronics and transistors at Stanford formed the basis for their research park, as did the chemical research in fabrics and textiles in North Carolina from Monsanto's initial development there. In Utah we thought we were pretty good in the biomedical field and pharmaceuticals, and with our initial work there in the artificial heart tests and development that we would naturally attract a great many in that field. We found, however, that there are some industry characteristics that do not always lend themselves to immediately picking up and moving someplace. Most of the pharmaceutical manufacturers are in the East, and some got as far as Midwest, but by their very nature they are quite conservative in their approach, and they are content to pretty well remain where they are and build up their research staffs where they are.

Now, we did get some fallout from that, but not the degree we anticipated. However, along came the energy problems of the early 1970's, and we found that in Utah we were sitting there in the center of a vast energy area, that our works in mining, metallurgy, and in the material sciences spawned a number of companies in the research park, and attracted some there that essentially formed the basis for our growth there. So while you might identify these and think of them as natural assets and resources, I would advise you to keep your mind open and pursue avenues in a number of areas because you do not always know what would have the greatest appeal to industry.

Senator HEFLIN. Dr. Lindsey, your testimony of the history at Research Triangle Park in North Carolina was very comprehensive, very complete, and most intriguing. The testimony, I gather, is that because of the different universities, and the danger of university competition, you had to have a centralized body to move forward with it, and of course, the State government occupied that role. You ended up with a Board of Science and Technology Development. I am looking to see in your testimony the exact title. What was that exact title again?

Dr. LINDSEY. Well, that is a central group, Senator, which was not really functioning at the time the Research Triangle Park was created. The Board of Science and Technology was established in 1963 by Terry Sanford when he was Governor. The main purpose at that time was to continue the means by which State government, private industry and academic institutions can work together for the development of the State, following somewhat the pattern of Governor Hodges in fostering cooperative working relationships similar to those that led to the creation of the park.

Governor Sanford's intent by creating this board, which he chaired, incidentally, and which Governor Hunt now chairs, was to further develop the strategy for economic growth of the State, drawing the universities, industries, and State and local governments into the process. Thus, the Board of Science was created after the park was established and hence was not involved in those early years.

I might add, Senator, if I may, that I went through my testimony very quickly. I was not here, unfortunately, when you began. I was not sure how much time I would have. But I want to commend you and your committee for all of the good work that has gone into S. 1286. I was trying to get my points in as quickly as I could, but there are many good things in this bill that I think are highly commendable.

Senator HEFLIN. Well, in the beginning, with your three universities involved, and your industry, was it necessary to have a central board or central governing body that made the decisions?

Dr. LINDSEY. Well, for the creation of the park in our circumstances, I think that was true. The Research Triangle Foundation served that purpose then and now. I think there are conditions, perhaps, where a research park, as a much smaller entity, can be organized by a university, for example. Just yesterday I was listening to President Low, of Rennsalaer Polytechnical Institute, describe the steps they are taking to create a research park as part of that institution. So far as I could tell from his testimony, they are not involving State government or private industry, as partners, in doing so. It is primarily a university undertaking on university-owned land.

So it depends partly on the scale and nature of what one is seeking to do. I was dealing with a large entity such as the Research

Triangle, which now has more than 5,000 acres in it. When you have more than one university, universities tend to compete with each other, and you need a unifying process. That is why Governor Hodges set up this committee in the exploratory stages of creating the park, consisting of representatives from universities, from industry, and from government to work out the details.

It would have been difficult, I think, to do it in any other way than through a joint committee of that nature. That committee later became the Research Triangle Foundation which is the organization that manages the resources of the park, selling tracts of land to industry or the Federal Government and State agencies—that is to whoever wants to locate a facility in the park that can comply with the qualifications.

Senator **Heflin**. Yes, sir.

Dr. **Money**. Senator, in that regard, in terms of organizations of parks and so forth, it has been my experience that there really is no model or example that will fit all situations. There are vast differences in governmental structures within a State, the educational circumstance, the location of the institution, the strengths of the university, the resources available, the land available, just a number of things that all have to be considered. And while it is a delicate fine-tuning to get them all together, there really is no one road to success or one example that would fit every one. You have to take what you have and go from there.

Senator **Heflin**. Let me ask generally about the bill as a whole. Do you see any relationship to business and government, primarily, that in trying to keep the technological lead that America has developed over a period of time, that there are some requirements of some exemptions on antitrust laws, for example, that there ought to be some type of changes relative to the patent laws? We have gotten into the patent laws where on the administrative procedures that they have gone through, we have one company that spent 11 years before it finally got a patent, and it was a 17 year patent, and 11 years of it had expired. So of course, you have got a Patent Restoration Act that is pending and that has some opposition. And then there is the possibility of some type of tax credit being used for various things.

Do you have comments, either one of you, do you foresee that a bill which is designed not just for a research park but primarily to—as Senator Gorton, in working with several of us, drafted this bill to try to regain America's technological advance, maintain it and see that we are not second rate to some of the other countries.

What areas do you see, do you feel that should be addressed or which are important to this issue?

Dr. **Lindsey**. Well, with respect to the patent issues, I think several more steps can be taken. Some significant changes were made a few years ago at the Federal level with respect to patent law and, in North Carolina, we are going through processes now of the changing policies of our universities and research institutions, and trying to update things consistent with that legislation and consistent with our own pursuits.

Additional effort is needed to compress the time it takes to decide to issue a patent, or not, to a much shorter period. We are taking much too much time to operate patent processes.

With respect to antitrust legislation, some liberalization of the situation has occurred in recent years, making it feasible, for example, for the Semiconductor Research Corp. to be organized, or the larger organization MCC, now located in Texas. The idea is to unify the basic research of several microelectronics companies in the United States so that they are not duplicating nor otherwise competing with each other unnecessarily conducting basic research.

That has become feasible. I suspect we could do more. I know that many of our industrial firms are somewhat gun shy about getting involved in any mutual effort of that nature.

We have in Research Triangle Park the Chemical Industry Institute of Toxicology, wherein the major chemical companies of the United States have unified their pursuit of research with respect to the toxicological effects of the major chemicals that each may be producing. In talking with the president of that organization, he tells me that they have to lean over backwards to be sure they are not violating some antitrust provision.

At the same time, we are enhancing in many ways our competitive conditions in this economy by stimulating small business development. Some of the things that Dr. Colton was describing also border on some of these issues when you have several firms unifying their efforts through a cooperative research program with the university.

I am not prepared to comment in detail on what might be done on both of these fronts, but you are raising important issues.

Dr. MONEY. Senator, with respect to the antitrust implications of the companies getting together to conserve resources and combine technological knowledge, they really do feel inhibited because of the very broad language in the Sherman Antitrust Law, you know, at anything that lessens competition. And we in Texas really are a little nervous still about that consortium being able to get together and work effectively because of that. While it is a great idea to locate that facility there outside of Austin and to utilize the resources there at the University of Texas, they really do feel inhibited because of that, and for that to be slowed down or hampered in any way would be tragic because they are attempting to bring on a line of this fifth generation microcomputers and microprocessing technology because we know that the Japanese are assiduously and aggressively working at that to get a quantum leap forward in that area and a great advantage in the competitive marketplace. And if we were to lose that by default some way, it would be I think most distressing. So in that regard, I would encourage you in your efforts to look at the implications of antitrust legislation.

Second, generally, anything that can be done to encourage and help small business, because there are statistics, and I am not prepared to quote the direct source or precise numbers, but in the magnitude of 60 to 70 percent of the jobs created in this country are in small business by the definition of the SBA. So whatever can be done in the way of taxation or liberalization of the antitrust or whatever to encourage that growth and development, it seems to me the economic world would cooperate in the regions in which they are located.

Senator HEFLIN. This bill calls for pilot programs dealing with retraining. We have had testimony before this Science and Technology Subcommittee that indicates we can expect in the future remarkable changes. I might have said buckle your seat belts. Technology, if you are tired of hearing of high technology, buckle your seat belt. You have not heard anything that is fixing to come in in the next 10, 15, 20 years, including the fact that some people predict that we will have to be retraining our work force every 10 years, and that even the graduate schools in the field of science may be inadequate as presently structured to train for the future or to instill the proper analytical discipline that may be necessary to compete in the future.

I just wondered if either of you have any comments on what you feel is coming relative to the work force in the normal context of what we call work force, and then what we would see in professional education and what demands you foresee that can be made as new and different technologies develop and emerge in the years ahead.

Dr. MONEY. Well, I am certainly no authority in the field of education, but let me say I was associated with Dr. David P. Gardner who headed the Commission on the Study of Education in the United States, and prior to the findings of that he initiated a program in Utah where he sent an open letter to all the parents of students, high school students in the State, and said in effect if you expect or your son or your daughter expects to be admitted to the University of Utah, that they must have a taken certain classes.—It was a beefing up of the experience in the hard sciences, in their classes, in sciences and mathematics, three complete units of English, and others which necessitated a good, strong look at the curriculum to get back into the more strenuous disciplines in preparation for university work. That has had, I think, a great effect, and we will continue to do that.

I am sure that higher education will be impacted by this and will have to look at the curriculum and make adjustments because when we see those in the Far East, in Korea, which was a devastated nation when I was there, is now an extremely strong economic force in the manufacture not only of high technology, but in steel and steelmaking and shipbuilding and the basic technologies or basic industries that were the strength of this Nation.

So yes, I think there are some dramatic changes coming, and we all need to be alert to them, and basically, if we can, I think, afford industry and education the opportunities to make these changes and to utilize the creativity and innovation within each of them, that we can rise to the occasion.

Senator HEFLIN. Dr. Lindsey.

Mr. LINDSEY. Well, I would quite agree, Mr. Chairman, that the issues you raised are extremely important. We are just beginning a tremendous transformation of our society. It is not just the economy. In my judgment, it is the whole society. The nature and role of government, the role of local communities, and other local components of the society are in involved in addition to the economic components.

In North Carolina in 1982, for example, we lost about 10,000 jobs in textile industry alone, partly due to the recession, partly due to the firms automating more, modernizing in order to stay in business in the realm of international competition. Without those changes, several of these firms would not have survived. We do not expect more than half of these 10,000 workers in the textile industry in North Carolina to be rehired as the economy picks up, because of automation.

At the same time, through new investments in new firms, and various other initiatives we have been taking, we have added about 22,000 new jobs that we know of. Of course, in addition to the textile industry we have lost jobs in other fields. So we are not necessarily maintaining a net gain in jobs.

As a part of our strategy, not only are we pressing forward in modernizing our traditional industries, such as textiles; we are also stimulating the growth of small business, placing emphasis on training and retraining, and education beginning at the elementary and secondary levels.

A few years ago we established a school of science and mathematics, keyed to the 11th and 12th grades of high school. It is a State residential school, designed to attract some of the best young students in the State. As we get a little farther along we will bring in some students from out-of-State. This is the manner in which we are spearheading improvement in education, particularly in science and mathematics.

Governor Hunt appointed, about 6 weeks ago, a State commission on education for economic growth, the purpose of which is to lay the foundation for broad-based improvement throughout our whole elementary and secondary education system. The intent is to make significant improvements in the rigor of elementary and secondary education in reading, mathematics, and so on. We have 58 community colleges in the State, 38 private colleges and universities, and 16 University of North Carolina campuses. This whole area of institutions is being included in the strategy for the State we are developing.

It is difficult, I think, to do these things in a coordinated way unless you have a clear role for State government, plus a lot of initiative and support.

Senator **Heflin**. Thank you.

Do you have a question?

Ms. **Coodley**. Yes.

Dr. Lindsey, I was very interested in your comments concerning the appropriate role of State government and initiatives such as the ones that S. 1286 envisions. I know that Senator Gorton would have wanted to follow up on that because it was a rather consistent theme of similar hearings which we held last month in Seattle, Wash., in which we heard from the State government about the role they saw for State government in research parks and collaborative research arrangements in universities and industry.

Right now as the bill is written, as you know, State governments are included within the definition of consortia that can participate in the cooperative agreements, and I am wondering, since you are suggesting that you see an even larger role, would you expand a little on that? If that does not seem to you to be sufficient to cover the kind of role that you would see, how would you suggest modifying the bill in order to give State government a larger role?

Dr. **Lindsey**. Well, certainly, as a minimum, it would seem to me the advisory committee that is now specified should include members from State goverment. State membership in consortia that enter into cooperative agreements, does not enable States to participate in the overall guidance of the program envisioned by S. 1286.

The key question is: How should we organize at both the Federal and State levels so that we are working together in this arena of activity we are discussing here today?

An example of a proposal that has been put forward is Representative Brown's idea of the National Technology Foundation. I have some trouble with that, as I have expressed to Congressman Brown, in that he does not say much about States in the last version, at least, that I saw.

I have reviewed at Senator Tsongas' consideration of what he calls an agency for technological innovation. I had hoped at one point that the National Science Foundation would exercise more leadership in this general arena as the major, central science agency of the Federal Government, working closely with the Science Adviser to the President, and the Office of Science Technology Policy. I do not see that happening much. NSF is not providing the kind of leadership of a broad strategy type that I think we are discussing the need for here today.

I am against creating another organization if we can avoid it. But I am also disappointed, and my friend here from NSF is with us, in the fact that NSF has not exercised the leadership needed, working with OSTP.

I think there needs to be further dialog between State leadership and Federal leadership—certainly Congress is involved deeply—in order to work this out. I do not have a clear answer at this point.

Ms. **Coodley**. Thank you.

Thank you, Senator Heflin.

Senator **Heflin**. I think we will take a 5-minute break. Any of you that want copies of various things that are here, if you have some type of card that you would like to give these gentlemen, I think they would be glad to mail you something.

Thank you.

[A brief recess was taken.]

Senator **Heflin**. Next is a panel of leading business and industrial leaders in Alabama. Mr. James C. Lee is the chairman of the board and chief executive officer, Buffalo Rock. Maybe that does not mean anything, but he has also been very active in putting together the research park for the metropolitan development board and the chamber of commerce.

Mr. Rodney C. Gilbert, the president of Rust International Corp., which is a part of Rust Kellogg, which is one of the largest engineering concerns of America and part of the Signal Group; and Mr. Sabert Oglesby, the president of the Southern Research Institute.

Mr. Lee, if you would start it off.

STATEMENTS OF JAMES C. LEE, JR., CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, BUFFALO ROCK; ED HARDIN, VICE PRESIDENT, RUST INTERNATIONAL CORP.; AND SABERT OGLESBY, JR., PRESIDENT, SOUTHERN RESEARCH INSTITUTE

Mr. **Lee**. Thank you, Senator.

We appreciate your being in Birmingham today, and your knowledge of what I am speaking of is so vast that frankly you almost have taken my speech and presented it in your great fashion because you have been so helpful in getting this matter of research and technology development in our area started.

We think that S. 1286 is a very fine bill, with certain changes that may be made in it, but the idea of what you are doing is great. It is no doubt that the bill is very much needed. If anything, it is long overdue in being produced.

I look upon it as an investment in the community and not a government give away program, and that is a vast difference and one of which I am sure the entire populace will enjoy and approve of.

I really believe that it is a case of a bill in the community being able to blend immediately into a success pattern by its implementation. Any help that Congress can give in further advancement in research should be money well spent, and it is important that ample funds be insured so it can have a substantial effect in a relatively short period of time.

We are all aware of the competitive balance going on throughout the world, and certainly our community approves of S. 1286 and what it is trying to do.

Now, let's talk about our specific area a little bit. When these things are developed, as they said this morning, it is important that they be turned into manufacturing processes, and we have already available 38 industrial parks with an area approximating 4,000 acres to take care of these processes when they come out of research, and this really allows the blending of completion of research to actual manufacturing with no loss of time. I think that is important.

We have applied and expect momentarily approval for a foreign trade zone. Our area is working very diligently to improve our exports plus the encouragement of foreign investments to come into our area because it is important that international trade be a two-way stretch. It has to move in both directions.

Now, let's take into consideration that land has not always been available in large quantities here in our area. In fact, it has been one of the detriments in our growth.

In fact, so much of our land was controlled by so few corporations, and they were not anxious at all in the past to sell this land. In the first place, in my opinion, they were not paying ample taxes on it.

So consequently, it did not cost them anything to not put it on the market or utilize it, and I am sure they would not agree with me on that, but that I think can be proved. That is not necessarily true today, but the fact is they have no need for the land any more.

The steel industry has taken severe cutbacks and the manufacturing industries along the lines with them have cut back so consequently it is more valuable for them now to sell the land or develop it, and it is an entirely different attitude among the corporate structure today.

In fact, in the past years they have been very cooperative in trying to work toward some solution for our community. We feel they have a moral obligation to this community to let land of this type be sold to people who will put it to a good social use as well as a manufacturing use.

So what are we doing about it now that the land is available? Well, we are just not sitting around doing nothing.

We are in the process of finalizing approximately 1,600 acres of land for a research and development park, and again I would like to reiterate the fact that the Senator has been very helpful in guiding us along these lines for a successful fruition of our plans.

This is a substantial commitment by the community in both public and private investments, and the nice thing about it is that there is additional land there which will allow us to go up to approximately 5,000 acres. These contracts unless there are some flaws in them at the last minute are basically going to be approved between now and the first of the year, and again, I would like to state that the corporate owners of these lands have been most cooperative in working this up.

Birmingham is very fortunate in being the home or is in close proximity to the leading universities of our State. Each of our institutions leads in certain types of research, and these universities work very closely together in being of help to others whenever they can.

They are not in the same field of research which assures a broad base of activity and should bring a very fine return on any Government funding.

In addition, Birmingham is the home of Southern Research, which has an oustanding record in cancer research, as well as the improvement of manufactured techniques of high technology. It has done extensive work in both the private and public sectors.

It may interest you to know that there are 500 companies in our area that are involved in certain high tech and related industries. They are involved in all aspects of engineering, health sciences, data processing and telecommunications. They employ 33,000 people with a $600 million-a-year payroll.

It is larger than a lot of people realize. You can see from that there is a substantial base which is already here to benefit and carry out the intentions of S. 1286. It further allows the potential research activities to get started on a fast track. It does not have to start from scratch.

Just a few blocks from this very location is the home of the University of Alabama, Birmingham, which is a national and world leader in medical research. People come from all over the world to utilize its facilities, and just in recent years the Congress of the United States set up the special John Sparkman Fund to allow UAB to work toward improving the health standards of other countries less fortunate than ours. Since 1970, over $300 million has been spent on construction at UAB.

They now have 5½ million square feet under cover, and the buildings should double in the next 15 years. It is now seventh in the Nation in Federal research grants of organizations of its type and totals over $50 million a year. As the Senator said, medical research technology is here.

They have just signed an agreement with Kyushu University of Japan, for joint research projects, and it was the first such agreement by this outstanding Japanese university with an American university. It is a fine example of institutions furthering international research, and certainly they work with other joint ventures in the private end.

We do not overlook the splendid work in research being done at the University of Alabama in Tuscaloosa, Auburn University and the University of Alabama in Huntsville, which is located in the heart of space technology development, and of course, Tuskegee is involved in certain research activities.

Now, I am interested in one of the panel—I mean, one of your members there, Senator, asking about the State of Alabama, and I am glad to tell you today that the State has recently formed an Alabama Research Institute that is actually operating. The meetings have been held, and it was given a $10 million plus grant as seed money.

The income from the grant will go to research activities in our State and can certainly be an adjunct to additional Federal funds. It will enhance the total valuation of the funding capital of both halves. The institute is certain to grow in the years ahead by both State and private funds, and you can see that it can work in close conjunction with S. 1286.

In closing, we wholeheartedly endorse S. 1286, but it is important that well endowed older organizations throughout the country not necessarily get all the majority of the funds. The organizations that have been in existence less years and are doing a great job should not be overlooked.

It is important that the younger aggressive growing organizations get their fair share. Communities such as ours that have excellent universities and research institutes should be encouraged in their activities provided by this bill, and would encouarge their commitments and give them added momentum.

Our area is the country's best kept secret. We have absorbed our industrial cutback, which has been substantial, and in spite of this cutback have added substantially in jobs in the past decade.

Let me mention that if you take the five largest corporations and cut back in heavy industry they have deleted approximately 35,000 jobs in this general area. If you multiply that to a 4-for-1 basis that is 140,000 people in the family units.

Now, that is larger than any municipality in Alabama with the exception of the four largest cities. We have absorbed that cutback. It is behind us basically now, and in spite of that have continued to grow in the decade of the seventies, and our service industry has increased over 54 percent in employment.

So this community is entitled to encouragement and help of S. 1286 It really deserves the support of Congress for what it has accomplished and what its forward development plans are. Our research is in place. Our commitment is in place.

Our pioneering has been started. Give us the additional momentum offered through S. 1286, and we guarantee you a splendid return on your investment, as well as making this world a better place to live.

Thank you, Senator.

[The statement follows:]

STATEMENT OF JAMES C. LEE, JR., CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, BUFFALO ROCK

Senator Heflin, thank you very much for the opportunity to discuss Senate bill 1286, and we appreciate very much you and your associates being in Birmingham for this presentation.

I would like to discuss the bill and then state why I think Birmingham is ideally situated for the utilization of research funds. There is no question that the bill is very much needed and if anything, is long overdue for its introduction. I look upon S. 1286 as an investment by the Government and not a Government give away program. This is an important difference and one that I think will be quite acceptable to the entire population. I sincerely believe that it is a case of a bill and a community being able to blend immediately into a success pattern by its implementation. Any help that the Congress of the United States can give in furthering the advancement of research should be money well spent and it is important that ample funds be assured so that it can have a substantial effect in research development in a relatively short period of time. All of us are well aware that we are in a world competitive battle that is going to require extra money and effort on everyone's part. Time is of the essence and our community certainly supports Senate 1286.

Now, let's move to our area and what we are doing to develop our efforts along these lines:

(1) We have already available 38 industrial parks, with area approximating 4,000 acres, to take care of manufacturing processes that will come out of this research. This allows the blending of completion of research to actual manufacturing with no loss of time.

(2) We have applied and expect momentarily, approval for a foreign trade zone. We are working diligently to improve our exports, plus the encouragement of foreign investments to begin businesses in our area. It is important that international trade move in both directions.

(3) We are in the process of finalizing the purchases of approximately 1,600 acres of land for a research and development park, with future plans to enlarge the area to approximately 5,000 acres. This is a substantial commitment by the community for its research development well into the future.

(4) Birmingham is fortunate in being the home or is in close proximity to the leading research universities of our State. Each of our institutions leads in certain types of research and the leadership of these universities works closely together in being of any help to each other that they can. They are not in the same fields of research which assures a broad base of activity and we feel would bring a find return on Government funding.

(5) In addition, Birmingham is the home of Southern Research Institute, which has an outstanding record in cancer research, as well as the improvement in manufacturing techniques of high technology. It has done extensive work in both the private and public sectors.

(6) There are 500 companies in our area that are involved in high tech and related industries. They are involved in all aspects of engineering, health sciences, data processing, and tele-communications. They employ 33,000 people with a $600 million yearly payroll. You can quickly see from these figures that a substantial base is already here to benefit from and carry out the intentions of Senate bill 1286. It further allows the potential research activities to get started on the fast track and not have to start from scratch.

Just a few blocks from this very location is the home of the University of Alabama in Birmingham, which is a national leader in medical research. People come from all over the world to utilize its facilities and in recent years the Congress of the United States set up the special John Sparkman Fund, to allow UAB to work toward improving the health standards of other countries less fortunate than ours. Since 1970, over $300 million has been spent on construction at UAB. They now have 5½ million sq. ft. of campus buildings and this should double in the next 15 years. It is now 7th in the Nation in Federal research grants, which now totals over $50 million a year. They have just signed an agreement with Kyushu University of Japan, for joint work on certain research projects.

It was the first such agreement by this outstanding Japanese university with an American university, and it is a fine example of two outstanding institutions furthering international research development.

Of course, we do not overlook the splendid work in research being done at the University of Alabama in Tuscaloosa, Auburn University and the University of Alabama in Huntsville, which is located in the heart of space technology development.

The State of Alabama has recently formed the Alabama Research Institute with a $10 million grant. The income from the grant will go to research activities in our State and can certainly be an adjunct to additional Federal funds. The institute is certain to grow in the years ahead by further State and private funds. You can see from these figures that we are now ready to move forward in conjunction with the help from the U.S. Government.

In closing, we wholeheartily endorse Senate 1286, but it is important that the well endowed older organizations throughout the country not get the majority of these funds. It is important that the younger aggressive growing organizations, such as we have in our State, get their fair share. Communities such as ours that have excellent universities and research institutes should be encouraged in their activities by help provided by this bill. It will encourage their commitments and give them added momentum.

Our area is the country's best kept secret. We have absorbed our industrial cutback, which has been substantial, and in spite of this cutback still have added substantially in jobs in the past decade. It has truly been a miracle and this accomplishment deserves the support of Congress in its forward development. Our research is in place, our commitment is in place, our pioneering had been started; give us the additional momentum offered through Senate 1286 and we guarantee you splendid return on your investment, as well as making our world a better place to live.

Senator HEFLIN. Mr. Gilbert, we will be delighted to hear from you.

Mr. HARDIN. First, Senator Heflin, I would like to express Mr. Gilbert's sincere apologies. He was unable to be here today and asked me to fill in for him, a poor substitute, but I will do the best I can.

I am Ed Hardin, vice president of engineering for Rust, and I would like to express my thanks to you, Senator Heflin, for sponsoring S. 1286 and giving us the opportunity to speak to you today about our feelings on the bill itself.

As you mentioned, Rust International is a subsidiary of Kellogg Rust, a member of the Signal Technology Group. Rust was founded in Birmingham in 1905 and currently employs over 1,100 engineers and technicians here in Birmingham, plus an additional 500 in our regional offices in Pittsburgh and Portland, Oreg.

In 1982 Kellogg Rust was designated as the leading U.S. design and construct firm by Engineering News Record. So from that, you can see that inasmuch as our primary source of income is derived from the industrial sector, the vitality of that segment of the U.S. economy is of real importance to us.

Now, over the past 20 years we have witnessed a steady erosion of the U.S. technological lead that we have enjoyed for so many years. Today it is not uncommon on major industrial projects to see a significant portion of the process technology and related equipment being imported from offshore.

Obviously, this has an adverse impact on our employment levels on the projects and represents a significant major loss to the total U.S. economy. It is difficult to fault the management of these firms for taking advantage of the latest processes that are available.

They would be remiss in their responsibilities if they did otherwise. But it is important that we do make a turn around in the technology shift and bring it back to the United States.

As Mr. Lee has mentioned, Birmingham has seen a very great reduction in our industrial base in the metals industry here. A significant portion of our labor population is unemployed as a result of either reduced production or total plan closings.

Yet because of some of the things that are happening here in Birmingham, we at Rust feel pretty excited about the opportunities that are here. The actions that the community leaders have taken to establish the research park, the growth in UAB and the programs there.

The plans for the center for applied industrial and applied research will certainly be of great benefit to Birmingham and the total area. We have been extremely pleased by the growth in technology here in the Birmingham area.

The growth of UAB, the emergence of Southern Research Institute as an internationally recognized research facility, leads Birmingham to the point that we do have a large technology population, certainly from an engineering standpoint, represented by Rust, Southern Company Services, Alabama Power, the Bell Companies, BE&K as well as a multitude of other, while small but highly capable, engineering firms.

In years past it was very difficult to recruit any significant numbers of engineering personnel in Birmingham, simply because they were not available locally, and to attract an out of state engineer to come to an area with a small engineering population was very difficult and expensive. Over the past few years we have found a change in that.

We do have certain areas that we do have difficulty in recruiting personnel, such as automation and control system specialists, but as the growth of our facilities here continue I feel that our problems there will lessen. Growth in R&D activities in Birmingham will benefit Rust certainly in other ways.

Obviously, we will gain from the increased industrial activity that will result from the development and implementation of improved technologies and manufacturing systems, be it on a local or national level. Moreover, having first rate research facilities close at hand will provide us with an opportunity, I feel, to participate more directly in those areas where we feel that we can make a meaningful contribution.

We are concerned that if the Birmingham activities must rely on private financing the time factor will be detrimental. Obviously, every day that we lose in making progress is simply putting us that much further behind.

I think it is because of this concern that we are pleased with the possibilities of S. 1286. Looking at the terms or the items covered in the bill, most of those are areas that we feel are vital to the upswing in U.S. industry. Automation, I think is the key factor; not just automation for the sake of automation, but to improve our systems so as to improve the quality of our work.

At Rust we employ more automation and control specialists than any other particular area simply because that is where we see the greatest activity at the present time. Something else that makes the research—S. 1286—attractive is that few engineering companies can afford to do research and development with internal financing, certainly not for the good of all mankind.

The competitive nature of our industry is such that this is not a very practical thing. Yet, these same engineering organizations do possess a major pool of talents that could make major contributions in the development and implementation of advanced manufacturing techniques. Under S. 1286 engineering companies such as Rust Kellogg would be encouraged to compete for the funds to actively engage its valuable pool of resources in the R&D efforts.

I am also pleased to see the provision in the bill to consider methods for the retraining of workers who have been displaced from declining industries. We have witnessed in many cases antipathy, even hostility, of the owner's labor force when we are trying to automate a facility. I think this is understandable.

Labor views automation as a threat to their continued employment, and unless there is a viable, well founded program to retrain a worker to elevate his or her skill level to the point that they can compete in the sophisticated automated facility, labor will continue to resist automation. I am pleased with that aspect of S. 1286.

However, there is one area that does concern me, and it is possible that I am not seeing the whole picture. The development in new technology is a great and wonderful thing, but the implementation of these advances is where the payoff comes. There exists in the marketplace today any number of proven technologies that would benefit the small manufacturing facility, but most do not have the funds or the resources to capitalize on the advances that are available.

Possibly, this might be the subject of later legislation, but I do feel that it is important to obtain some support for the small manufacturing firms to input and utilize some of the techniques that are available today.

Senator, this pretty well sums up my comments, and I appreciate the opportunity.

[The statement follows:]

STATEMENT OF ED HARDIN, VICE PRESIDENT, RUST INTERNATIONAL CORP.

I would like to express my thanks to you, Senator Heflin, and to each member of this subcommittee for allowing me this opportunity to speak in support of Senate bill 1286. This bill, when enacted, will be a vital force in returning the U.S. industrial sector to its rightful position at the leading edge of technology.

Rust International Corp. is a wholly owned subsidiary of Kellogg Rust Inc., a member of the Signal Technology Group. Rust was founded in Birmingham in 1905 and currently employs more than 1,100 engineering and technical personnel based in Birmingham in addition to over 500 others located in our regional offices in Pittsburgh, Pa. and Portland, Oreg. Kellogg Rust was ranked by *Engineering News Record* as the leading U.S. design and construction firm for the year 1982. Inasmuch as our primary source of income is derived from the expansion and modernization of industrial facilities, the vitality of that segment of the U.S. economy is of prime importance to my company.

Over the past 20 years we have witnessed a steady erosion of the technological leadership that the United States once enjoyed. It is not uncommon on major industrial projects to see a significant portion of the process technology and related equipment imported from foreign industries. Obviously, this has a direct adverse impact upon our employment levels on the projects and it further represents a considerable loss to the overall U.S. economy. Yet, one cannot fault the management of these new facilities for their decision to select the best processes available in the marketplace. They would have been remiss in their responsibilities had they done otherwise. The burden of guilt for this technology shift must be shared by all of us—private industry, the engineering community, labor, the research establishment, and all levels of government.

Birmingham has seen its industrial base in the metals sector reduced to a shadow of its former size due to our inability to compete with foreign imports. A significant segment of our labor population is currently unemployed as a result of reduced production or total plant closings. Yet, there is clause for optimism. The community leaders of Metropolitan Birmingham have recognized the critical need for concentrated, continuing efforts in the research and development of new technologies and manufacturing systems. You have already heard, or will hear today, testimony describing the Birmingham Research Park, UAB's center for industrial and applied research and the incubator facilities. These are real activities that are taking place because of Birmingham's awareness of the critical need for industrial research and development.

At Rust we are excited by the action that is taking place in Birmingham. Over the recent years we have been a steady expansion of technological skills in the area as demonstrated by the phenomenal growth of UAB and the emergence of Southern Research Institute as an internationally recognized research facility. Birmingham is becoming acknowledged as a professional center with a large engineering community represented by Rust, Southern Company Services and BE&K as well as a multitude of smaller but highly capable engineering firms. It is a fact that talent attracts talent; technology attracts technology; and engineers attract engineers. In years past it was difficult and expensive for Rust to recruit engineering personnel inasmuch as they were not available locally and those from out of State were reluctant to relocate to an area with a limited engineering population. Although we still find it difficult to recruit locally certain of the skills that we need, particularly in the area of automation and process control, the growth of Birmingham's technological sector has made it much easier to attract most of the engineering disciplines that we require. We are confident that as the local R&D efforts in Birmingham grow our recruiting difficulties will continue to decrease.

In addition to the larger technology base to draw from, the increased industrial research and development activities and facilities in the Birmingham area will benefit Rust in other ways. Obviously, Rust will gain from the increased industrial activity that will result from the development of new or improved technologies and manufacturing systems, be it on a local or national level, simply because that is the marketplace in which we operate. However, having first rate R&D facilities close at hand will provide Rust with the opportunity to participate more directly in these areas where we feel that we can make meaningful contributions.

While we are confident that the Birgmingham community activities will succeed, we also recognize that obtaining adequate funding and investments from the private sector will take time to develop. Every day that is lost puts us that much farther behind in the marketplace. we can ill afford any further degradation of our position.

It because of our concern about the potential late timeframe of success in Birmingham if forced to rely solely upon private financing that makes Senate bill 1286 such a critical piece of legislation. A study of S. 1286 indicates that the bill addresses those areas that are most essential to the revitalization of U.S. industry. At Rust, we have recognized the importance of advanced techniques in computer-aided design, automated materials handling systems, automated storage, and retrieval systems, automated sensing and testing systems, the development of machine and process control strategies and the utilization of computers to obtain maximum automation of manufacturing facilities. We have far more people dedicated to automation and controls than to any other specialized field and are maintaining a continuing inhouse training effort to further strengthen our capabilities. We are pleased to note that the UAB School of Engineering is one of the few schools in the United States to also recognize the importance of this specialty and has added a full process control option to its electrical curriculum.

Due to the highly competitive conditions existing in the engineering profession as a result of the depressed domestic market, few engineering firms can afford the luxury of self-financed research and development. Yet, these same organizations possess a major pool of resources that can make major contributions in the development of advanced manufacturing techniques and systems. Under the provisions of S. 1286, engineering firms such as Kellogg Rust will be encouraged to compete for the necessary funding to actively engage this valuable pool of talent in the R&D effort.

I am especially pleased with the provision in the bill to retain workers who have been displaced from declining industries in order that they can be productive in the more sophisticated environment of a highly automated facility. Rust has witnessed at first hand the antipathy, even hostility, of the owner's labor force where automated systems were being installed. The labor force understandably views automation as a threat to their continued employment and until there exists a viable, well founded program to provide the necessary retraining to enable a worker to elevate his/her skill level, labor will continue to resist automation. I am aware of industrial societies such as American Foundryman's Society that are struggling to develop such retraining programs with extremely limited funding.

Senator Heflin, I commend you for your sponsorship of S. 1286 and I urge this subcommittee to strongly support its speedy enactment into law. Time is not in our favor in the international marketplace.

Senator **Heflin**. Thank you, Mr. Hardin.

Mr. Oglesby.

Mr. **Oglesby**. Thank you, Senator.

I appreciate your coming to Birmingham and your interest in our science and technology work here in Alabama. The invitation to appear before this subcommitee suggested that I address the role of research parks in stimulating technological innovation and economic growth.

It is a little bit presumptuous of me to talk about research parks in this respect because I have never really been associated with a research park. On the other hand, I have been involved in research and development work for about 35 years, and the organization that I represent, Southern Research Institute, has been a vital factor in the economy of Birmingham in developing research and technology capabilities.

I think in terms of a research park in the Birmingham area that is one of the advantages that we have over some other areas. That is, having Southern Research Institute here with a fairly substantial volume of research represents a plus for getting such an organization started.

Research parks in general have a number of advantages. From the standpoint of the occupants of the park, they provide a centralized location for people that are engaged in highly technical types of work.

Even though the companies that occupy the park are engaged in different businesses, there is often a lot of synergism that gets involved between the different companies, and the individuals involved can communicate both socially and otherwise. It is a great advantage to be able to talk to engineers and scientists who are engaged in the type of business that you are.

One of the other major benefits, I think, in a research park is that there are library facilities and computer facilities that are available to new companies that are located in a park. I think those of us who have to support libraries and computers recognize that this represents a substantial expenditure, and small businesses simply cannot afford to have the library facilities that can be afforded in a research park.

Here in Birmingham we have a very substantial library, as does the University of Alabama in Birmingham, and small businesses located here would certainly have access to these libraries and also to the computers.

The third advantage to a research park is it provides a technological labor base. I think that most companies that want to locate in any place look at the labor base, and research organizations certainly have to look at the technological labor base. If there is a backlog of scientists and engineers in the area, it certainly makes a big advantage in locating at that particular spot.

Still another advantage of a research park is the potential for interaction with the local university. The teaching staff of the university can provide a very substantial source of supplementary personnel, as well as consultants to operate in specialized areas. So for these and for many other reasons research parks have been very successful.

From a community standpoint, the major advantage of a research park is the jobs provided by the occupants of the park. The industries that move into research parks are generally nonpolluting and very desirable types of industries.

The tenants of a research park, for example, employ something in the neighborhood of now around 20,000 people, many of whom are scientists and engineers. Not only is the number of people important, but the educational level of the staff is generally higher than average which helps to support cultural and civic activities of a community.

So because of these and other advantages of a research park to a community, there has been a considerable interest on the part of most States and many communities in establishing a research park or in attracting so-called high tech industry. So the competition among States is very intense.

In reviewing the history of research parks, there have been a number of successful ones, many that fall in the intermediate range, and there has also been a number of failures, some of which involve attempts associated with reasonable good universities. So one must conclude, I think, that establishing a research park is not without some risk. Just providing land is not sufficient inducement for attracting suitable tenants.

To illustrate the competition for research parks, I understand that during the past 12 months there have been official delegations from 38 States that have visited Research Triangle Park for the purpose of obtaining information to pursue development of research parks. One of the ingredients that appears to make for a successful research park is the proximity of a facility that dispenses substantial funds in technological areas, such as Government agencies or companies that receive large Government contracts.

I think here in Alabama we have one of the classic examples of such a park in the Cummings Research Park in Huntsville. There is also a group of companies that operate in Government facilities. They are called Government owned contractor operated facilities, and these include Los Alamos, Oak Ridge National Laboratories, Lawrence Livermore Laboratories, Wright-Patterson Air Force Base, Sandia, and many other organizations.

Looking at the literature, I find that quite a number of these States in which these organizations are located are trying now to establish research parks based on the proximity of these organizations.

The second ingredient is the proximity of a world-class university or at least a university with a very substantial graduate level program. I think there are many examples of successful parks in which the ingredients of a world-class university has made the difference between maybe a mediocre park and a very successful one.

Among these are the Forrestal Research Center near Princeton, and Stanford Research Park and many of them are located near MIT. There are some moderately successful parks that seem to have survived without either ingredient, but most of the unsuccessful ventures would seem to have neither of these two vital ingredients.

A third factor that is very important seems to be the wholehearted support from local and State government and industrial leaders. Research Triangle Park, for instance, has benefited from the personal efforts of Gov. Luther Hodges and Governor Hunt.

The recent allocation of about $25 million in State funds to build a microelectronics center is an example of the type of support that is needed to accelerate the success of a research park. There are several factors that should be considered regarding establishment of a research park in an area.

First, it is not a quick fix for a depressed economic situation. Even the successful parks have taken many years to develop, and I believe it is unwise to picture the establishment of a research park as the economic salvation for a community that has economic problems.

It is also unwise, I think, to consider that establishing a research park will necessarily spawn numerous spinoff companies. Such has not been the experience with many parks.

For example, I think Mr. Lindsey reported that there has not been that many spinoff operations in Research Triangle Park, which is certainly one of the more successful. There are some exceptions, and I think that Huntsville is one of the exceptions because there are a number of spinoff operations from the Cummings Research Park that are noteworthy.

I think in looking over the information I have it seems to me that most of the spinoff operations result from the fact that these companies that move into research parks receive funds from the Federal agencies nearby, and that generates ideas that have commercial potential.

Well, I think since competition for attracting new companies to the many research parks is so high, one alternative is to develop industries based on ideas from the community. Incubator concepts have been developed to provide laboratory space and consulting on both technical and business matters to assist an engineer or scientist in bringing an idea to a marketable position.

One factor that would enhance this concept is a relatively recent policy by the Federal Government to award greater rights to universities and nonprofit institutions on patents resulting from Government-sponsored research. The reasoning behind this concept is that unless a company has patent protection they will not spend the money necessary to commercialize the product.

This policy has not been in existence long enough for an evaluation of its effectiveness, but there are many examples of licensing agreements within the past 2 or 3 years for commercialization of products resulting from Government-sponsored research.

We at Southern Research have several patent licensing agreements with companies for manufacturing products that have been developed based on the Government research that we have done, and I am sure UAB has the same. Communities with research organizations engaged in Government research would then have a number of advantages in identifying some opportunities for businesses, small businesses based on Government-sponsored research.

I think that research parks are a great idea, and we at Southern Research certainly lend our support to the idea of research parks based in the Birmingham area. But I think that there are certain reasonably well-defined criteria for the development of a park, and I think that the main point that I would like to make is that with the competition for research parks that is bound to develop and has already developed, it is going to take a lot of effort on our part.

I think with people like Jimmy Lee and others who are behind it, I believe that we are going to be successful, but there are not going to be, and I think that we need to be darned sure that we are not one of those that are going to fall by the wayside.

I think to end my remarks I am reminded of the old spiritual that says, "Everybody talking about heaven ain't going there."

[The statement follows:]

STATEMENT OF SABERT OGLESBY, JR., PRESIDENT, SOUTHERN RESEARCH INSTITUTE

The invitation to appear before this subcommittee suggested that I address the role of research parks in stimulating technological innovation and economic growth. In some respects, I am not really qualified to discuss the impact of research parks on technological innovation since I have never been directly associated with a research park development. On the other hand, my background in the field of research and development may be relevant to a somewhat detached and objective view of research parks.

As I view the concept of research parks, they provide a centralized location for companies engaged in some type of research or light manufacturing which employs a high percentage of technically trained personnel. There are several apparent advantages to a centralized location. First, there is an opportunity for technology exchange between companies and individuals even though they are engaged in different fields. Such synergism often results in solutions to problems or new products that can be beneficial to all parties. Concentration of personnel with varying disciplines can also be beneficial to companies needing a specialized service not available on their staff.

Another benefit to be derived from a centralized location is availability of library facilities. It is extremely costly to provide complete coverage in even a single field of technology, and having access to libraries covering different fields of technology is a distinct advantage.

A third advantage to a research park concept is that it provides a technological labor base. Just as any conventional company would consider the availability of skilled labor in choosing a location for expansion, companies involved in research and development must consider the availability of technically trained personnel in choosing a location.

Still another advantage to a research park is the potential for interaction with a local university. The teaching staff of a university can be a valuable source of supplementary personnel or consultants in specialized areas, as well as providing personnel through effective graduate programs.

So for these and other reasons, many research parks have been successful.

From a community standpoints, the major advantage of a research park is the jobs provided by the occupants of the parks which are generally desirable, non-polluting businesses. The tenants of Research Triangle Park, for example, employ something in the neighborhood of 17,000 people, many of whom are scientists and engineers. Not only is the number of employees important, but the educational level of the staff is generally higher than average which helps to support cultural and civic activities of a community.

Because of these advantages of a research park to a community, there has been a considerable interest on the part of most states and many communities in establishing a research park or in attracting so-called high tech industry. So the competition among states is very intense. In reviewing the history of research parks, there have been a number of successful ones, but also there have been many failures, some of which involve attempts associated with reasonably good universities. One much conclude that establishing a research park is not without considerable risk. Just providing land is not sufficient inducement for attracting suitable tenants.

To illustrate the competition for research parks, I understand that during the past 12 months, official delegations from 38 states have visited Research Triangle Park for the purpose of obtaining information to pursue development of research parks.

One of the ingredients that appears to make for a successful research park is the proximity of a facility that dispenses substantial funds in technological areas, such as government agencies or companies receiving large government contracts. Examples of such parks are the Cummings Research Park in Huntsville, many parks located near Silicon Valley in California, and those located near Boston. A second ingredient is the proximity of a world-class university. Examples of parks meeting this criteria are the Forrestal Research Center near Princeton, Stanford Research Park, and those located near MIT. There are a few moderately successful parks that seem to have survived without either ingredient, but most of the unsuccessful ventures would seem to have neither of these two vital ingredients. A third factor that appears to be important is whole-hearted support from local and state governments and industrial leaders. Research Triangle Park, for example, has benefited from the personal efforts of Governor Luther Hodges and Governor Hunt. The recent allocation of $25 million to build a microelectronics center is an example of the type of support needed to accelerate the success of a research park.

There are several factors that should be considered regarding establishment of a research park in an area. First, it is not a quick fix of a depressed economic situation. Even the successful parks have taken many years to develop. I believe it is unwise to picture the establishment of a research park as the economic salvation for a community that has economic problems.

It is also, I believe, unwise to consider that establishing a research park will necessarily spawn numerous spin-off companies or new start-up companies. Such has not, I believe, been the experience with many of the parks. There are some exceptions, primarily with organizations supported by substantial government funding, such as around a major government facility. The pattern here seems to be that commercial potential is recognized for defense research or other government-supported research.

Since competition for attracting new companies to the many research parks is so high, one alternative is to develop new industries based on ideals from the community. Incubator concepts have been developed to provide laboratory space and consulting on both technical and business matters to assist an engineer or scientist in bringing an idea to a marketable position. One factor that would enhance this concept is a relatively recent policy by the federal government to award greater rights to universities and non-profit institutions on patents resulting from government-sponsored research. The reasoning behind this concept is that unless a company has patent protection they will not spend the money necessary to commercialize a product. This policy has not been in existence long enough for an evaluation of its effectiveness, but there are many examples of licensing agreements within the past two or three years for commercialization of products resulting from government-sponsored research. Communities with research organizations engaged in government research would have some advantages in identifying opportunities for businesses based on government-sponsored research.

To sum up my feelings about research parks, the concept has proven advantageous to both the tenants and the community in many instances. There does seem to be reasonably well-defined criteria for development of a successful park, and communities contemplating development of a park should examine their positions and the probabilities for success.

The number of communities caught up in the desire to establish a high tech industry will result in many attempts to develop research parks with various mixes of light industry and research-oriented business. It is apparent that all of these attempts will not be successful. One is reminded of the old spiritual which goes "Everybody talking about Heaven ain't going there."

Senator **Heflin**. Well, thank you.

Mr. Oglesby, just for the record, could you tell us a little bit about Southern Research Institute. Of course, I think we all know about the cancer research.

Tell us a little bit about what other research is being done there today.

Mr. **Oglesby**. I would like to do one other thing, Senator. When you are in Birmingham I would like to give you a personal invitation to come by and we will show you firsthand what we have over there.

I think we have a very interesting organization. Our work at Southern Research—Our research is divided into six major research departments. We have an environment research department that is working in the field of environmental control, including removal of sulfur oxide from fluoric acid from industrial processes.

We have worked for a number of years on particular removal devices including electrostatic precipitators developing special instrumentation for measuring particle sizes and other things associated with air pollution control.

We have a mechanical engineering group that is one of the leaders in developing materials for aerospace applications. We have worked with almost all of the major aerospace companies on developing advance material for rocket nozzles, nosecones, things of this sort.

Then for the missile command up in Huntsville we have developed several guidance systems for missiles, including the present guidance system for the Fog-D fiber optic guided missile. We have also developed the guidance system for the Air Force's Maverick missile which has been in production, and it is a viable instrument, a viable missile in our arsenal.

We have done a lot of work in chemistry and polymer development, and one of the exciting areas that we have at the moment is in our controlled release work. We are one of the leaders in the country in controlled release of biologically active agents, and that includes such things as controlling fire ants. We have developed a fire ant toxicant.

Senator **Heflin**. Well, thank the Lord. I have all the farmers in the world talking to me about that.

Mr. **Oglesby**. We think that one is going to be marketed as soon as we can get it through EPA approval. It is going to be marketed by a company located in Georgia.

Senator **Heflin**. What was the other one, Mirex?

Mr. **Oglesby**. Mirex was environmentally unacceptable, and not only you, but all of our board is interested in this fire ant toxicant. I do not think we ever have a board meeting but what somebody asks what the status of our fire ant toxicant is.

We have worked on long acting contraceptives, injectable contraceptives. These are for developing countries where one can inject a small dose of this material and have it effective for 3 to 6 months.

We have worked on fluoride releasing devices that are controlled release that have a very good probability of reducing tooth decay and cavities, much below what is available from either fluoride in the water or from mouthwashes or toothpaste.

Senator **Heflin**. Has there been a relationship between the dental school and you in that?

Mr. **Oglesby**. Very much so. We have worked very closely and very cooperatively with the university here, and on the contraceptive work we do the formulation and polymer work and they do the work on the baboons and things of this sort to show its effectiveness.

On the fluoride releasing device we have developed the basic device. They have worked with us on attachment to the teeth and things of this sort. So we can just kind of go on and on of the things that we have going on but——

Senator HEFLIN. Are you doing anything in metallurgy now?

Mr. OGLESBY. Yes; we have a metallurgical research group, and they are working mainly in the foundry metals business and working—their principle sponsors are the American Foundrymen's Association, the Steel Foundry Society of America, and many companies including some of the big companies like John Deere, International Harvester, Ford, on developing new processes and methods for working in the foundry.

Senator HEFLIN. How many employees do you have at Southern Research?

Mr. OGLESBY. We have at the present time, I think the last number I saw was 604, and our business volume——

Senator HEFLIN. How many of those are professionals?

Mr. OGLESBY. About two-thirds.

Senator HEFLIN. Two-thirds professionals.

Mr. OGLESBY. And we are projecting a business volume next year of around $25 million.

Senator HEFLIN. Thank you, sir.

Mr. Hardin, you mentioned, of course, Rust Engineers and you gave us a background of about 1,100 engineers and technical employees of Rust Engineers, Rust International Corp. here in Birmingham. There are others that you have mentioned, and in Mr. Gilbert's written testimony that he prepared, I think he brings out that there are—Birmingham has become acknowledged as a professional center with a large engineering community represented by Rust, Southern Company Services, BE&K, as well as a multitude of smaller but highly capable engineering firms, and I suppose also that South Central Bell's engineering armada is in that group, too.

They have a large group. Do you have any idea, say within the Birmingham area how many engineers, graduate engineers are there working or employed in the Jefferson County area?

Mr. HARDIN. My best guess would be about 4,000.

Senator HEFLIN. Around 4,000.

Mr. HARDIN. Yes, sir.

Senator HEFLIN. How many—now, you said technical. Do you know anything that BE&K, how many engineering and technical employees that they might employ?

Mr. HARDIN. Well, I would—I could make a guess.

Senator HEFLIN. Well, just give us a ball park.

Mr. HARDIN. I would say in the 200 number.

Senator HEFLIN. 200, in that number.

What do you do in Rust International, you're in design and construction, what are you primarily working on now?

Mr. HARDIN. Well, right now we have just completed the engineering for the United States Steel casting machine and seamless tube mill. We are also involved in the design of a new cigarette making plant for R. J. Reynolds Tobacco Co. in Tobacco Belt, N.C.

Senator HEFLIN. That is right close to that Triangle.

Mr. HARDIN. Right close, Senator. That is a major sized project with about 1 million man hours of engineering activity on it.

We are doing a number of projects in the Pulp and Paper Industry; a little bit of work for Alcoa Aluminum at the Alcoa facility in Tennessee; some work for Inland Steel, two casters for Inland Steel; and doing work for the Corps of Engineers on the Chemical Decontamination Training Center at Fort McClellan.

We have some work underway for Weyerhaeser on the west coast, and we are quite active in the refuse to energy business. We have currently got three projects under design and construction now to burn refuse and create power from it.

Senator HEFLIN. BE&K is a design, engineering and construction company. It is my understanding they are doing a considerable amount of work in the building of new paper mills, conversion of pulp to paper with the idea of environmental controls designed to eliminate the smell and the various other problems with it, and they have been quite successful in that aspect.

Mr. HARDIN. Yes, sir, we both share that marketplace.

Senator HEFLIN. You both share that market. You all are a little competitive——

Mr. HARDIN. Well, we are friendly competitors.

Senator HEFLIN. Well, just sort of give a little background here of what you do. What relationship have you had with universities?

We have heard from Mr. Oglesby relative to the Southern Research Institute. What relationship do you have with existing universities in this area?

Mr. HARDIN. In terms of research?

Senator HEFLIN. Yes; research or cooperation.

Mr. HARDIN. Well, we are interested in all of the engineering activities of the various schools. The University of Alabama School of Engineering has been very helpful to us, particularly when they introduced the process control option in their electrical engineering program, one of the few schools in the United States that does offer that option. With our interest in automation control that makes it very attractive to us. We work to support the schools were we can financially.

Senator HEFLIN. Well, are some of those professors acting as consulting engineers?

Mr. HARDIN. Yes, sir. We utilize some of the faculty members to work with us on special occasions. We also—A number of our employees act as part-time faculty.

Senator HEFLIN. They have adjunct professors at UAB.

Mr. HARDIN. Yes; and it has been a very rewarding experience, I think, for all that have participated in that activity.

Senator HEFLIN. Well, I think that is just some of the spinoff and not in the terms of new things, but the relationships of adjunct professors by which professional companies, engineering companies provide to a university and then the consulting engineering facilities that universities can provide to a company is a form of cooperation that exists.

Mr. HARDIN. And it is very helpful to us to be able to call upon the faculty members.

Senator HEFLIN. You all might get together and see if you have got some joint things that you want to do together and talk to that man from the National Science Foundation and get that seed money while you are here.

Well, I think we will adjourn now. We have a luncheon for visiting witnesses. If you do not know where it is Mike Gilliland will tell you, but be back at 2 o'clock and we will complete the hearings at that time.

Thank you, everybody, for attending.

AFTERNOON SESSION

Senator **Heflin**. Well, we will resume our hearing.

We have a panel of distinguished educators who are vitally interested in research and technology. Dr. Mack Portera, vice president for external affairs, University of Alabama; Dr. Robert Glaze, the vice president for research and institutional advancement of the University of Alabama in Birmingham; Dr. Paul F. Parks, vice president for research for Auburn University; and Dr. James Woodward, the dean of the school of engineering of the University of Alabama in Birmingham.

We welcome you gentlemen to us. May I start with Dr. Portera, start and go across.

We had really hoped that Dr. Joab Ed Thomas could have been present. He was Chancellor at the University of North Carolina State and was involved in the creation of the Research Triangle Park in North Carolina and very much involved, but he had another commitment today, but he sent a very able substitute. Mack, we are delighted to have you.

STATEMENTS OF DR. MACK PORTERA, VICE PRESIDENT FOR EXTERNAL AFFAIRS, UNIVERSITY OF ALABAMA; DR. ROBERT GLAZE, VICE PRESIDENT FOR RESEARCH AND INSTITUTIONAL ADVANCEMENT, UNIVERSITY OF ALABAMA IN BIRMINGHAM; DR. PAUL F. PARKS, VICE PRESIDENT FOR RESEARCH, AUBURN UNIVERSITY; AND DR. JAMES WOODWARD, DEAN, SCHOOL OF ENGINEERING, UNIVERSITY OF ALABAMA IN BIRMINGHAM

Dr. **Portera**. Thank you, sir. It is nice to be here. He does send his apologies. He is out of State at the present time attempting to generate some funding to support a project that is very much in line with some of the things that we have been discussing today.

On behalf of him and the University of Alabama I wanted to express our appreciation to you, Senator Heflin, and to the members of the Science, Technology, and Space Subcommittee for your work and your efforts in scheduling what we believe an important hearing in the State of Alabama. We think that it is especially appropriate that you schedule such a hearing in this State for a number of reasons.

First of all, we believe that the role of Alabama in space exploration and the Nation's space flight program is unrecognized in many parts of the country. The space flight industry is an important part of the economy of north Alabama and the State in general, and we Alabamians are very proud of the contributions we have made in this State to our Nation's goals in space exploration.

Second, our State has experienced unusually severe effects from the Nation's economic slump, and we are anxiously and aggressively searching for new and better ways to maintain and enhance existing industries while attracting additional industry to the State of Alabama.

Finally, there are what we believe to be some unique relationships that are developing in Alabama between higher education, Government and industry that we believe could serve as national models.

Let me comment briefly, if I may, on the two items that are on the agenda for today. First of all, S. 1286 entitled "Manufacturing Sciences and Technology Research and Development Act of 1983.

First, I would say that we in higher education, the University of Alabama especially, are in complete agreement that industry, Government, and higher education have not devoted sufficient attention to improving this country's competitive position in the world marketplace by conducting and applying research designed to improve manufacturing processes.

Second, the state-of-the-art manufacturing technology is not being implemented in this country as rapidly as is the case in several of our neighboring countries and with several of our chief competitors.

Finally, as a result of this oftentimes severe lag between development and implementation of manufacturing technology, the American industry in certain areas is losing larger shares of world markets.

Recognizing this type of situation existing in our country and in the State of Alabama, our institution has attempted to respond to some serious problems, especially those that are facing our automobile industry, and I wanted to talk a little bit about one of those today and relate that to S. 1286.

Recently, we at our university established with the General Motors Corp. and United Auto Workers an agreement that we think can be built upon and that has great potential for our State and for the Nation. Dr. Colton this morning from the National Science Foundation referred to that relationship.

It is probably better described in the materials that I have attached to my remarks in the New York Times article and the Time magazine article that, as I said, are attached to my remarks. We, General Motors, United Auto Workers and the university have saved a plant and 225 jobs that were scheduled for elimination in Tuscaloosa in May 1982 by identifying and implementing new and efficient manufacturing processes.

General Motors was losing $2 million a year in operating costs in our local fuel systems plant. GM and UAW working together identified a cost savings in the amount of about $1.5 million; came to the university and asked us to find for them at least a half million dollars in operating costs.

We took the challenge they had offered us which was to save a half million dollars in operating costs a year over a 3-year period, or pay the corporation $500,000 a year for 3 years. We agreed to assist the corporation and the union in implementing what is called a "Factory of the Future" in our community over a 3-year period.

Today, 10 months after we created the Applied Research Laboratory we have exceeded our cost savings goal by about $150,000 and are busy working with the corporation on the implementation of new and better technologies in the plant. Eight schools and colleges on our campus, the faculty and students in those schools and colleges are engaged in 42 projects at the present time with General Motors and UAW in an attempt to make that plant more efficient, and to begin to establish in our community a "Factory of the Future."

Early in our work with General Motors and United Auto Workers we recognized the need to create within our university an academic plan that would seek to insure that we at the university were offering the instructional and research programs that are necessary to support industrial efforts at establishing modern, state-of-the-art manufacturing processes.

This plan is described in the attachment that I have attached to my remarks, and as you will note its aims are almost identical to those that are described in S. 1286.

Senator **Heflin**. Would you explain in a little more detail about it to some of us who have not had an opportunity to read your attachment?

Dr. **Portera**. Early on in our work with General Motors Corp. it became evident to us that to establish their first factory of the future in Tuscaloosa it would be necessary for us to build on some existing strengths at our institution, primarily in the areas of the College of Engineering and our College of Commerce on the campus.

The areas included computer-aided engineering, production systems management, materials management, and human and social systems in a high technology environment. We identified the areas of strength that existed on our campus early on in the work, and decided that we needed to build on those areas of strength and to create some new areas of strength there at the institution.

We knew we had to hire some new faculty. We had to hire some post doc graduate assistants and purchase equipment in key areas. A large portion of the purchase of equipment would be in the area of computing.

So we put together with the corporation and with the union a plan that is a 3- to 5-year plan for us that will allow us by acquiring additional financial resources that we are pursuing at the present time that will allow us to build strengths in those four areas.

As we approach the implementation phase of the plan that is outlined in the attachment we find ourselves in a situation approaching the first year where we have raised about $1 million of the $2.8 million that we believe we need in the first year of our operation. Needless to say, additional support such as that that might be offered in S. 1286 would be of great assistance to us at this time.

As Dr. Colton indicated this morning, we are pursuing with the National Science Foundation a cooperative effort between NSF, the University and several industries in the State of Alabama. We are presently negotiating with three other industries in the State to establish agreements that are similar to the ones that we have with General Motors Corp. and with UAW.

I am here today to say that we wholeheartedly support S. 1286 because we are convinced that other institutions of higher education, as well as ourself, industry and State government will support this program.

As we continue to build on the relationship between General Motors, other industry and the university, we envision additional industrial development in our community and in our State, and we believe that by assisting existing industry we can cause them to become stronger, more competitive, and as a result, gain a larger share of the market share. As with research park developments, the relationships between higher education and industry will be strong and beneficial to all concerned.

We believe that an effective working relationship between industry and higher education will be necessary. In fact, we believe they will be demanded in the future.

These relationships should and will span a continuum from cooperation in recruiting graduates of institutions to cooperative research relationships. Of course, the research park concept provides the most extensive type of relationship between industry and higher education.

As was noted in our session this morning, it offers opportunities for joint research, joint use of equipment and facilities, sharing of faculty and staff, job assignments for students, both graduate and undergraduate, and opportunities to shape curricula and research programs, and I could go on and on.

We enthusiastically support these types of relationships, and we encourage all institutions to pursue them. Certainly, it is our belief that our doctoral granting institutions in the State of Alabama are capable of significant research and that they should pursue relationships such as this.

Thank you.

[The statement follows:]

STATEMENT OF DR. MALCOLM PORTERA, VICE PRESIDENT FOR EXTERNAL AFFAIRS, UNIVERSITY OF ALABAMA

On behalf of The University of Alabama I want to express appreciation to you, Mr. Heflin, and to the members of the Science, Technology, and Space Subcommittee for your efforts in scheduling this important hearing in our State. We believe that this meeting is especially appropriate for our State for three reasons. First, the role of Alabama in space exploration and this Nation's space flight industry is an important part of the economy of North Alabama, and we Alabamians are proud of the contributions that have been made by our State to our National goals in space exploration. Second, our State has experienced unusually severe effects from the Nation's economic slump, and are anxiously and aggressively searching for new and better ways to maintain and enhance existing industry while attracting additional industry to our State. Finally, there are some unique relationships that are developing in our State between higher education, government, and industry that may serve as national models.

Let me comment briefly, if I may, on Senate Bill 1286 entitled "Manufacturing Sciences and Technology Research and Development Act of 1983." First, we are in complete agreement that industry, government, and higher education have not devoted sufficient attention to improving this Country's competitive position in the world market place by conducting and applying research designed to improve our manufacturing proccesses. Second, state-of-the-art manufacturing technology is not being implemented in this country as rapidly as is the case in nations that serve as our chief competitors. Finally, as a result of this oftentimes severe lag in time between development and implementation of manufacturing technology, American industry in certain areas is losing larger shares of world markets.

Recognizing that this type of situation certainly exists with America's automobile industry and responding to a potential plant shutdown in Tuscaloosa, our University has established a unique relationship with the General Motors Corporation and the United Auto Workers that has great potential that I would like to describe to you. This relationship is probably better described in The New York Times and Time Magazine articles that are provided with copies of my remarks.[1] We (G.M., U.A.W., and the University) have saved a plant and 225 jobs that were scheduled for elimination in Tuscaloosa in May of 1982 by identifying and implementing new, efficient, manufacturing processes. G.M was losing $2 million a year in operating costs in a local fuel systems plant. G.M. and U.A.W. identified a cost-savings effort that would reduce their operating costs by $1½ million. The University agreed to find at least $500,000 in additional cost savings and to assist the Corporation and the Union in implementing a "Factory of the Future" in our community over a three-year period. Today, just ten months after we created the "Applied Research Laboratory" we have exceeded our cost savings goal by about $150,000 and are busy working with the Corporation on the implementation of new and better technologies in the plant.

Early in our work with G.M. and U.A.W. we recognized the need to create an academic plan that would seek to ensure that we at the University were offering the instructional and research programs that are necessary to support industrial efforts at establishing modern, state-of-the-art manufacturing processes. This plan is described in the attachment[2] to my remarks, and, as you will note, its aims are almost identical to those described in S 1286. The plan was developed in conjunction with General Motors Corporation and with Alabama-based industries, and its reflects our best efforts to identify areas of research strength, areas with research potential, and sources and levels of expenditures needed for effective implementation of our Advanced Technology and Productivity Transfer Program. As we approach the implementation phase of our plan we find that we have for our first year's operation. Needless to say, additional support such as that which might be offered in S 1286 would be of great assistance to us at this time.

We wholeheartedly endorse the approach that you are taking with S 1286. We are convinced that other institutions of higher education, industry, and state government will support this program.

As we continue to build on the relationship with General Motors and others, we envision that additional industrial development will occur; and, as importantly, we believe that existing industry that we assist will become stronger, more competitive, and as a result of growth in market share, will expand. As with research park developments (which we strongly support) the relationships between higher education and industry will be strong and beneficial to all concerned.

Senator HEFLIN. Thank you, sir.

The next witness is Dr. Robert Glaze, the vice president for research and institutional advancement, University of Alabama in Birmingham.

Dr. Glaze, we are delighted to have you here and appreciate hearing from you at this time.

Dr. GLAZE. Senator, it is a great pleasure to welcome you on behalf of UAB and our president, Dr. Hill. We consider the matters before this committee of great interest to the American people, and certainly of special and particular concern to those of us in the university community here in Alabama.

I would like to take the time allotted me today to talk a bit about my institution, keeping in mind that I want to talk about how we exemplify some of the things we have heard this morning. One of the common threads in discussing research parks which went throughout all of the testimony today was that the successful efforts throughout the country over the last 20 to 30 years have without exception been in close geographical apposition to a major research institution or institutions.

Why is this so? I would like to talk about that a little bit and how the institutions represented at this table before you can serve in our local setting. We hope to provide a similar success in Alabama.

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[1] Retained in committee files.

[2] Retained in committee files.

UAB which is a comprehensive urban research university is one of those universities which in recent years has seen a very significant increase in industrial interest in the work going on in our laboratories and our hospitals. In like manner, there has been enhanced interest on the part of our faculty in the technology being developed in industrial laboratories.

To give you some perspective on this, in 1981 at UAB out of a total of about $50 million of research volume a year we had $1.7 million of direct industrial support for research efforts at UAB. This has increased since 1981 until at the current time it is roughly $4 million.

There has been an almost explosive increase in the numbers of projects. Many of these are fairly small, in the neighborhood of $10,000 to $20,000, but the exchange of technology and conversation between industrial scientists and our scientists has increased enormously in the last few years. This is similar to what has been going on all over the country.

While most universities do not receive a major portion of their research support from industrial concerns, it is an important part of what we do, and it will grow in importance as the years proceed, I am certain.

I would point out that this whole matter has been well discussed and documented in the last annual report of the National Science Board, and a number of others have particularly addressed themselves to these recent developments. At UAB the interest in our laboratories has largely centered in the biomedical health care field because of our international reputation in those disciplines.

However, it is very much intensified because of our urban setting, and this has been seen in urban universities throughout the country. To put it very bluntly, we could not even if we wished to escape the attention of those industries in our community.

They want the expertise on our faculty. They want the use of our libraries and other facilities, and they us seek out on their own without any encouragement on the university's part, oftentimes, collaborative arrangements.

I am sure Dr. Woodward, dean of our school of ngineering could give you many, many examples of this in his own area, and there are many other examples throughout the institution. Because of the proximity to a large urban setting much of this easily occurs.

For instance, our schools of engineering and business have recently occupied a new building, the majority of support of which was raised in local business and engineering communities because these companies insisted that we expand our educational offerings and research ventures in areas where they needed manpower, they needed expertise, and they needed collaborative efforts.

In a further response to this sort of demand the university has established a center for industrial and Applied Research to serve as a focal point for some of these applied research interests of local industries. This is a mason organization, but one which we see growing greatly in the future years.

We already have many specialized centers of research and I will not enumerate them but give one example. In the school of dentistry we have established an office of applied research which serves as a central focus for work with dental supply companies and drug companies who wish to have drugs tested in the dental clinics or new dental materials explored, and this has been an enormously satisfactory and productive effort.

There are a number of these sorts of focal points throughout our institution and others which are increasingly becoming a focus of industrial collaboration. We have heard a lot of discussion about how the university is involved with local business community and govermment in developing a research park, but also we are working on the development of a so-called "incubator" facility which will provide itself as a hatchery, if you will, for small technology based industries.

Collaborations within the university involve many different departments with a particular emphasis in our institution on biomedical and health care disciplines. But one of the important facets of any such development is going to be the collaboration, as Dr. Portera has already pointed out, of faculties in the schools of business and management.

Throughout the Nation in the development of small technology related businesses the one most important thing which is required is the availability of good management advice. More of these small businesses fail not for lack of expertise and technology, but for lack of expertise in management. So this is a real source which we feel the university might provide in such a study.

In short, in an urban university we do not see these relationships with industry as something peripheral to our mission as a public institution. Joint ventures with and services to the governmental and industrial communities are essential to our mission part of why we are really here.

It might be helpful to take a few minutes explaining why recently in the biotechnology and biomedical related fields close collaboration between universities and private industry has received so much national attention, with many large universities entering into multi, multimillion dollar contracts with private pharmaceutical industries. There is a reason why this has happened, and I think it would be instructive to look at this for a moment.

What has happened is that basic biomedical research work over the last several decades has been used to develop new drugs, devices and technology which are going into the hospitals and doctors' offices, and offices of other health care professionals to provide improved, more efficient health care.

This is creating many, many new markets, and new companies are being formed overnight as these new technologies are moved into the marketplace. These developments are happening extraordinarily fast in areas such as the application of computer technology to diagnostic and therapeutic devices and the development of new drugs and modes of therapy, many of these now involving genetic engineering and recombinant DNA techniques.

Often the only people available to apply the new knowledge because it is moving so rapidly, the only people who can apply this knowledge to the development of new products are those people who developed the basic information, the scientists in the university research laboratories, and this is the new and different aspect of all of this. In years past it is usually 10 or even 20 years from the time a basic discovery is made in a laboratory until an application is even envisioned in the marketplace, and maybe another 5 to 10 years before that discovery is used to develop products and they are tested and put in the market.

Today, in many instances that time is foreshortened and the transition from laboratory to the store shelf can be a matter of 6 months to 2 years. If you think about it for a minute in the past we in the universities have been able to train a generation of scientists who have the new knowledge and have the new techniques available who can then go work in industry and take that knowledge to develop the new products. These days technology often is moving so fast that only the universities have the experts to develop the technology, and thus unless the university people work toward the commercialization of the product it simply will not be commercialized until people trained in the techniques have actually matured, moved out of the university and become employed in industrial settings.

I go through all this and take the time to do it because I think it is important to emphasize we must maintain an atmosphere with the new technologies in which university people can be involved in product development. Something not foreign to people in the engineering disciplines, for example, but in such things as biomedical research and health care it is a new development in the lifestyle of those disciplines. We want an environment which can result in products which will provide a stimulus to the economy of this country, and of course, we also hope to Birmingham and the State of Alabama.

Our institution is working very much toward those ends in a number of different ways and very much support the concepts of the bill being considered today and also the development of research parks.

What is the appropriate Federal role in all of this, which is in essence what we are considering here today. I think it is important to back off and consider a couple of things, and then I would like to consider one particular area which the bill does not address but which my colleagues and I think is very important. It is no accident in this country that the scientific disciplines in which the United States is considered a world leader, for example, microelectronics, computer science, biotechnology, health care and the pharmaceutical industry, are the very same areas where the Congress of the United States and the Federal executive have provided consistent, evenhanded and reasonable levels of support for basic fundamental research ever since World War II.

As a result, we as a nation have a pool of technical manpower in these areas second to none in the world, and it is this base of knowledge which has allowed our industrial sector to develop an advantage over other countries in the world.

Alabama in partiular should be proud of the role of Senator Lister Hill in the evolution of much of this support, particularly in the biomedical area.

But it should never be forgotten by any of us that the current vitality of these industrial areas in this country and the opportunity for growth and continued leadership in these segments of business is fundamentally dependent on a pool of exquisitely well-trained manpower. It is not things that create these new products; it is people.

We need this manpower, both in our Nation's universities and our industries. No technological society can prosper without a continued supply of such trained manpower and the fundamental research activity which produces the ideas on which to base industry and product lines of tomorrow.

I believe whatever additional actions are taken by the Congress to promote university-industry collaboration there must be a continued and indeed enhanced support for basic scientific research and research training, not only in the areas mentioned above but in other areas. We should support not only the collaboration and development of applied research, but we must continue to provide adequate support for basic research.

We should learn from our successes as well as our failures. We as a nation must assure that there is a future supply of well trained manpower, new ideas and basic scientific activity on which the technologies of tomorrow can be based.

With this as background then, I want to center in on one area in which I think the Federal Government has a very important role to play.

The bad news is that little to nothing is being done in this particular area at the present time. The good news is that it will not cost a lot of money for the Federal Government to have an effective and highly important role in promoting university-industrial collaboration in the way in which I am going to suggest.

It has been my experience, and I would suspect that of my peers sitting at the table as well as many others, that the most effective collaborations among scientific organizations occur when individual scientists in different groups have an opportunity to work in each other's laboratory for an extended period of time, relatively unfettered, operating as real colleagues and collaborators.

There is absolutely no substitute for this sort of experience in the development of productive and highly effective scientific work. Basic scientific research is a very personal matter, and if people are going to work together they have got to spend extended periods of time together.

This is true whether we are talking about basic research, applied research or the direct development of new products. One of the most difficult and trying tasks I have as a university administrator—and this is true of many other people—is finding the resources and the money, if you will, to assist our faculty and students to work in the institutions, be they universities or in industries for a sabbatical leave or for a 3-month summer experience.

Those kinds of funds are very hard to come by. Similar difficulties exist in many companies, particularly the medium sized and smaller companies who just are often unwilling or frankly if they are smaller companies unable financially to provide leave for extended periods of time for their employees to go to universities for collaborative work. Thus, it is tough to move the people across the barrier between university and industry.

It seems to me that it would be very worthwhile if the National Science Foundation or the Department of Commerce as part of the program under consideration in the bill we are addressing today could develop a fellowship or similar program to allow the exchange of trained scientific personnel between universities and industrial laboratories. This would be very important in providing university personnel with a better understanding of the problems associated with the product development and commercial development of technology, and it would also refresh the outlook of industrial people, giving them a better understanding of what the very latest thing, the cutting edge in a particular discipline is being done, if you will, in university laboratories, and give them some insight as to where new developments might come from and various areas of technology.

Such a national program supported by the Federal Government, probably with some appropriate matching requirements from the university and industry—I have not thought through the details of such a program—I believe would bear fruit for the economic development of many of our technically based industries far beyond the dollars involved, and I believe such a program would be accepted by both the university and private sectors enthusiastically.

I have sensed in the past private industry being very reluctant to accept direct Federal support from any efforts because of potential strings attached. I think this is unlikely to be a problem with such a fellowship program if properly structured, and I believe it would be very effective and cost a relative pittance in terms of the amount of money required to have a significant impact.

In conclusion, I want to commend the committee for its concern and interest in the matters before these hearings, and certainly pledge my institution's support for enhanced collaboration between research universities and industry.

Senator **Heflin**. Thank you, Dr. Glaze.

[The statement follows:]

STATEMENT OF DR. ROBERT P. GLAZE, VICE PRESIDENT, RESEARCH AND INSTITUTIONAL ADVANCEMENT, UNIVERSITY OF ALABAMA IN BIRMINGHAM

I am Robert P. Glaze, Vice President for Research and Institutional Advancement, at the University of Alabama in Birmingham (UAB).

On behalf of UAB and our President, Dr. Hill, I want to welcome you to Birmingham and Alabama to tell you how much we appreciate your concern and interest in the matters under consideration at these hearings today.

Our institution, a comprehensive urban research university, is one of those universities which has seen in recent years a significant increase in industrial interest in the work going on in our laboratories and hospitals. In like manner there is an enhanced interest by faculty in our institution in research collaboration with industrial scientists.

In 1981 there was $1,763,639 in industrial support for research at UAB. This has increased in 1982 and 1983 to $2,577,233 and $3,998,150, respectively.

Similar growth in collaboration by the university and industrial sectors is apparent nationwide as documented by the last annual report of the National Science Board [1] and elsewhere. The interest at UAB has centered in the biomedical/health care fields and has been intensified because of our urban setting. As has been pointed our recently in an address to the annual meeting of the American Association for the advancement of Science by David Admany,[2] President of Wayne State University:

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[1] "University-Industry Research Relationships: Myths, Realities, and Potentials" 14th Annual Report, National Science Foundation, 1982.

[2] Science, vol. 221, pp. 427 (1983).

"The urban universities are likely to produce significant adaptations of the industry-university relations developed elsewhere. Partly this reflects the character with business and industry in the urban centers. Hence, much applied university research will be in areas important in traditional heavy manufacturing, whether in production processes or product quality or work force productivity.

"Urban adaptations of university involvement in the economy will also reflect the underdevelopment of urban universities. Their research base has been only two or three decades in the making, compared to a century of activity in our leading private universities, principal state universities, and land-grant institutions. . . Consequently, I believe that urban universities will relate their efforts to business in ways that will be dramatically different from the formulations employed by other public institutions.

"For instance, I believe that much of the research activity of urban universities will take place directly on the premises of major business enterprises located near them. These enterprises have the capacity to invest in modern laboratories and equipment, which are difficult for urban universities to afford. Any they will have an incentive to make such investments if there is a good prospect for product or productivity improvement and if they are able to displace some of their costs for R & D personnel by having university scientists undertake these activities. Even more striking, I believe, will be the tendency for graduate and specialized undergraduate instruction to follow faculty activity onto private premises."

I provide this quotation since it is germane to the discussions here and the experience of our institution. We could not, even if we wished to, escape the attention of those industries in our community which seek out the expertise and facilities or our institution in a number of collaborative arrangements. For instance, our schools of Engineering and Business have recently occupied a new building the majority of support for was raised in the local business and engineering communities, because of their insistence we expand our educational offerings and research ventures in these areas of direct application to their businesses.

In a response to this demand we have established a Center for Applied and Industrial Research within UAB to serve as a focal point for the interest of industries in collaborative endeavors, and we have specialized centers already operating in the institution; for example, the Office of Applied Research of the Dental School which provides a specialized point of contact for pharmaceutical and dental supply companies interested in product testing and research collaboration.

As will be and has been discussed by others today, the University is very intimately involved with the local business community and government in not only developing a research park but in providing support for the development of a so-called "incubator" facility to serve as a spawning ground for technology related industries. These collaborations run the gamut of disciplines within UAB, with a particular emphasis in our institution on biomedical and health care-related disciplines, although there is a rapid growth in other areas of the institution as well.

In short, in the urban university we do not see these relationships as something peripheral to our mission. Joint ventures with and service to the governmental and industrial communities are actually central to our mission, a part of our raison d'etre.

As I mentioned there has been a great deal of national interest in university-industry collaboration in biotechnology-biomedical related fields. This has indeed very much been the experience in our institution and it may be useful to take a short time explaining why this has received so much attention in recent years.

Basic biomedical research work over the last several decades has been used to develop new drugs, devices, and technologies which are entering into the clinic and the offices of health care professionals to provide improved, less expensive and more efficient health care. New markets are being created and new companies are being established as these new technologies are moved into the market place.

These developments are moving extraordinarily fast in areas such as the application of computer technology to diagnostic and therapeutic devices and the development of new drugs and vaccines. Often the only people available to apply the new knowledge to the development of new products and modalities of therapy are those same scientists who made the fundamental discoveries.

In years past, it might be five, ten, or even twenty years from the time that a basic discovery is made in the laboratory until an application is seen in the marketplace for this discovery and appropriate products are developed and tested. Today in many instances that time is greatly foreshortened and the transition from laboratory to the store shelf is a matter of months to a few years.

In the past we in the universities have been able to train a generation of scientists expert in new techniques, and then they move into the industrial laboratory and manufacturing facilities to develop new products.

Today technology is moving so fast that in some areas often time only universities have the experts who can develop the technology and, as a result, unless these university people work toward the commercialization of the product, it simply will not be commercialized until people are trained to work in the industrial setting with the new technology. Thus, it is important that we maintain an atmosphere in which university people can be involved in product development and which can result in products which will provide a stimulus to the economy of this country and we also hope Birmingham and Alabama.

Certainly our institution is working towards this in trying to facilitate the establishment of small companies by our faculty members and also we are working, as you will hear from other today, towards the establishment of a research park in which larger companies can build facilities for R&D and light manufacturing.

It is no accident that the scientific disciplines in which the United States is considered a world leader—microelectronics, computer science, biotechnology, health care and the pharmaceutical industry—are the very same areas where the Congress of the United States and the Federal Executive have provided consistent, evenhanded and reasonable levels of support for fundamental research ever since World War II. Alabama should be proud of the role of Lister Hill in the evolution of much of this support. It should never be forgotten that the current vitality of these industrial areas in this country and the opportunity for growth and continued leadership in these segments of business is fundamentally dependent on a pool of exquisitely well-trained manpower, both in our nation's universities and industries. No technological society can prosper without a continued supply of such trained manpower and fundamental research activity on which to base industry and product lines of tomorrow. I believe whatever additional actions are taken by the Congress to promote university-industry collaboration, there must be a continued and, indeed, enhanced support for basic scientific research and research training, not only in the areas mentioned above but in other areas. We should learn from our successes as well as our failures. We as a nation must assure that there is a future supply of well-trained manpower, ideas, and basic scientific activity on which the technologies of tomorrow can be based.

With this background I want to center on one area in which I think the Federal government has an appropriate and important role to play. The bad news is that little to nothing is being done in this area at the present time. The good news is it will not cost a lot of money, in my view, for the Federal Government to have an effective and highly important role in promoting university-industry collaboration.

It has been my experience that the most effective collaborations among scientific organizations occur when individual scientists in different groups have an opportunity to work in each other's laboratory for an extended period of time, unfettered, as true colleagues and collaborators. There is absolutely no substitute for this sort of experience in the development of productive and highly effective scienfitic work, whether it be in basic research, applied research, or the direct development of new products.

One of the most difficult and trying tasks we university administrators have is finding the money to assist faculty and student researchers for work at other institutions, including industries. Similar difficulties exist in companies, particularly medium sized to small companies, who are often unwilling to provide leave for extended periods of time for many of their employees to go to universities if they cannot see a short term or bottom line gain. It would be worthwhile to pursue the development of a fellowship or similar program to allow the exchange of trained scientific personnel between universities and industrial laboratories. This would be very important in providing the university personnel with a better understanding of the problems in product development and commercial development of technology, and would also refresh the outlook of industrial people giving them a better understanding of the very latest of what's going on in university laboratories and of where the new developments they are attempting to apply are likely to come from.

Such a national program supported by the Federal government, probably with some appropriate matching requirements, I believe would bear fruit for the economic development of the technological side of the industries in this country far beyond the dollars involved, and I believe would meet acceptance in both the university and private sector sides. In the past private industry has been reluctant to accept federal support because of the potential strings attached. This is unlikely to be a problem in such a fellowship or manpower exchange program and I cannot overstress the importance of such an effort.

In conclusion, I want to commend the concern and interest that these hearings signify and pledge my institution's support for enhanced collaboration between research universities and industry.

Senator **Heflin**. We are delighted to have Dr. Paul Parks, the vice president for research of Auburn University. I understand now there is a story going around that says there are three flies. One of them is a Georgia fly, one of them is an Alabama fly, and one of them is an Auburn fly, and they ask how can you tell the Auburn fly? They say you can tell him because he is in the Sugar Bowl.

We will be delighted to hear from you, Dr. Parks.

Dr. **Parks**. It was a good weekend for us, Senator.

First, let me thank you on behalf of Dr. Bailey for bringing these hearings to the State, and for allowing us to testify on these most important matters. I appreciate the opportunity to join my colleagues from UAB and the University of Alabama, on this panel.

I also appreciate the opportunity to present testimony concerning potential cooperative activities among industries, universities, and Government that could lead to enhanced industrial and economic development in the State, the region, and the Nation.

We are all well aware of the deterioration of our relative competitive position in the world market. I certainly do not intend to belabor that point today. I simply want to point out that industries, Government, and universities must join together in a common effort to develop and implement new technology if we are to stem this tide and make our products competitive in the world market.

Few topics are more important or pertinent to the long-term economic welfare of this Nation than the question of how the United States will meet the challenge of its leadership in manufacturing and technology. I would like to briefly comment on the matter of research parks and spend the remainder of the time talking about S. 1286.

Auburn University fully supports the initiative being taken by the community leadership in Birmingham in establishing a research park. We believe that this is an important initiative and one we will fully support from our university.

But let me make these points. There is no question that established research parks—those of the Silicon Valley, Route 128-Boston, Research Triangle Park and others—offer an environment for significant contributions to science and technology essential to economic development.

However, it is impractical to assume that the unique conditions that led to the establishment of these successful parks can be duplicated in every State. In any case, the time required to establish such parks is considerable and does not offer short-term assistance for the widespread improvement of the Nation's industries.

We tend to forget that the Research Triangle opened in the late 1950's and some 7 years later had only two major tenants. That is not in anyway to speak against research parks, but simply to remind us all that there is a significant time delay in the initiation of such a park and a significant contribution by those parks to the economic environment of the State or region.

I certainly believe we should continue to develop research parks where favorable conditions exist, but I suggest there is a more direct, immediate way that States such as Alabama may promote the technological development of its industries and provide an excellent vehicle for cooperation among industries, Government, and universities. Furthermore, my proposal is directly related to the objectives of S. 1286.

I propose the establishment of regional advanced manufacturing technology centers with the following objectives: (1) to educate men and women who understand, advocate, and can help implement the advanced manufacturing concepts that are essential to the future of industry in the region and the United States as a whole; (2) to provide research that will make the United States a leader in the discovery and application of high technology and manufacturing and will keep the Nation at the forefront of these developments; and (3) to provide assistance to industry in the application of advanced manufacturing technology to specific manufacturing processes.

Now, the first two of these are, I think, relatively straightforward and we understand the educational and research function here, but the heart of the testimony that we would like to offer today has to do with this third item, that is, how we go about providing assistance to industries in the application of this new technology.

U.S. manufacturing companies are showing a growing interest in the application of advanced concepts to the manufacturing enterprise. Companies are realizing that in order to compete in today's world market they must rely on the creative developments that are taking place in manufacturing technology.

Techniques such as computer aided design and computer aided manufacturing are being incorporated into the development of computer integrated manufacturing systems. These systems employ computer assisted design and control from the initial order to final product delivery.

Operations from product design, to parts fabrication and assembly, to product delivery are being organized, scheduled, and controlled by computers. Although these concepts are at the leading edge of technology, they are already being implemented by some of our larger manufacturing companies.

While the larger corporations in this country have the research and development base and the investment capital to design and install advanced manufacturing procedures, there are many small industries that cannot afford the investment unless they can assess beforehand how the advanced technology might work in their particular industry and whether it will provide a satisfactory return on investment.

This lies at the heart of our testimony, and it refers back to an issue raised by an earlier speaker this morning having to do with how we bring smaller industries in this Nation into this new technology movement. The proposed advanced manufacturing technology centers will have the capability to develop prototpye manufacturing systems for specific applications in these smaller industries, and to allow evaluation of the advanced technological procedures in the improvement of productivity and efficiency.

If I might summarize this particular part of the testimony, the centers will allow the small industry to understand the new technology and evaluate the appropriateness of the technology before investing in and installing an automated process. They will know whether it would work in their industry and what the capital investment would be before they commit to that kind of investment in their own industry. That is simply what we are saying.

These centers would be especially important in the Southeast where the number of relatively small manufacturing operations is particularly large. The ultimate survival of these smaller industries—this is important—the ultimate survival of these smaller industries, which collectively form the backbone of America's industrial strength, may well depend on the speed with which CAD/CAM technologies are employed.

The new technology should allow existing industries in States such as Alabama to improve their competitive positions in the world market. This is important because in my opinion the renewal of our existing industries rather than the influx of new industries will be the primary basis for economic recovery in Alabama. Or, as Dr. Money pointed out this morning, many of these will be homegrown industries that will find their roots in the State.

Regionally this fact is supported by a recent report from the State of Georgia that most of the new jobs within that State came from the expansion of companies already in the State rather than influx of new industries. There are precedents, by the way, for setting up these centers to provide prototypes to assist in evaluating advanced manufacturing techniques.

The Japanese company, NEC Ltd., has established a plant to evaluate advanced manufacturing methods for new products before going to production. They do this at a separate plant. They work out all the procedures, the automation, and then they move the whole system to a plant where the manufacturing will take place.

George Devol, the developer of industrial robots, proposes to develop the most automated plant in the world and rent it to manufacturers. A group of manufacturers in conjunction with a university has established an automation center to allow potential users to gain experience in solving manufacturing problems, and West Germany established a test facility for robots at a university which is available to the industries in that company.

There is some activity in the United States. Generally, however, it is less intense and lacks the coordinated contributions that S. 1286 affords. As an example, Purdue University is developing on its campus a laboratory that is essentially an automated factory.

But I am here to tell you today there is a need much closer to home for this kind of initiative. Alabama is one of the leading manufacturing States in the Southeast.

In the primary and fabricated metal industries, it leads other Southern States in employment and value added. Recognizing the dependence of the Alabama economy on manufacturing and in keeping with its land-grant tradition, Auburn University is proceeding with the establishment of an advanced manufacturing technology center.

Already we are modifying our educational program to incorporate such technologies as CAD/CAM and robotics. We are performing research in advanced manufacturing technology areas, and we have assisted industry in the application of the technology.

I might say as an aside that we already have several projects funded by the National Science Foundation or are in the process of negotiating with the National Science Foundation for support in the area of advance manufacturing technology. We also propose to offer a short course or a meeting on our campus in the spring to bring industrial leaders in to discuss the whole area of advanced manufacturing technology to get their ideas on how the university should proceed in this initiative.

But we need to do more. We need to accelerate the technology transfer particularly within our smaller industries. To accomplish this we must develop prototype manufacturing systems for industrial application.

By demonstrating and evaluating these advanced manufacturing technologies in specific applications, we believe that we can substantially accelerate the application of these techniques. We are hopeful that funds for the intitial development of this capability can be obtained through legislation such as S. 1286.

We are confident that once this capability is developed we will be able by successful application to attract the industrial support necessary to sustain the operation of the center. The regional advanced manufacturing technology centers offer an excellent oportunity for cooperation among industries, government and universities.

It is a team effort. Government can provide the initial development capital through legislation such as S. 1286 although in our opinion the level of funding for the cooperative agreement would probably need to be increased in order to develop several such centers within this country.

Universities can operate these centers and are willing to do so, and industries can support and expand these centers through sustaining memberships and user fees. It is our anticipation that when such centers are established that certain industries would in fact be members of such organizations paying annual fees to make use of those centers, and others who had some more random or periodic use would pay a user fee to make use of these facilities.

I urgently request that the Committee on Commerce, Science, and Transportation give serious consideration to the establishment of the proposed advanced manufacturing technology centers at appropriate universities as the committee explores ways to promote technological innovation throught cooperation among industries, Government and universities.

We certainly support S. 1286 and believe it is the right direction, and we wish you well in your further work on this piece of legislation.

Thank you, Senator.

[The statement follows:]

STATEMENT OF DR. PAUL F. PARKS, VICE PRESIDENT FOR RESEARCH AND DEAN OF THE GRADUATE SCHOOL, AUBURN UNIVERSITY

I appreciate this opportunity to present testimony concerning potential "cooperative activities among industries, universities and government that could lead to innovation and new technology." Few topics are more important or pertinent to the long-term economic welfare of this Nation than the question of how the United States will meet the challenge to its leadership in manufacturing and technology. The United States has seen its share of the world gross national product decline from one-third to one-fifth over the past 20 years while Japan's share increased from less than 3 percent to approximately 10 percent. Industries, government, and universities must join together in a common effort to develop and implement new technology if we are to stem this tide and make our products competitive on the world market.

I have been asked to testify on two topics: the "role of research parks in stimulating technological innovation and economic growth" and "S. 1286, a bill to fund research in advanced manufacturing techniques." Regarding the first, there is no question that established research parks (Silicon Valley, Route 128-Boston, Research Triangle Park, etc.) offer an environment for significant contributions to science and technology essential to economic development. However, it is impractical to assume that the unique conditions that led to the establishment of these successful parks can be duplicated in every state. In any case, the time required to establish such parks is considerable and does not offer short-term assistance for the widespread improvement of the Nation's industries. We tend to forget that the Research Triangle opened in the late 1950's and some seven years later had only two major tenants.

I believe we should continue to develop research parks where favorable conditions exist, but I suggest there is a more direct, immediate way that states such as Alabama may promote the technological development of its industries and provide an excellent vehicle for cooperation among industries, government, and universities. Furthermore, my proposal is directly related to the objectives of S. 1286. I propose the establishment of regional Advanced Manufacturing Technology Centers with the following objectives:

(1) To educate men and women who understand, advocate, and can help implement the advanced manufacturing concepts that are essential to the future of industry in the particular region and the United States as a whole;

(2) To provide research that will make the United States a leader in the discovery and application of high technology in manufacturing and will keep the Nation at the forefront of such developments;

(3) To provide assistance to industry in the application of advanced manufacturing technology to specific manufacturing processes.

While the first two objectives are straightforward, the third requires further explanation. United States manufacturing companies are showing a growing interest in the application of advanced technology concepts to the manufacturing enterprise. Companies are realizing that in order to compete in today's world market, they must rely on the creative and innovative developments that are taking place in manufacturing technology. Techniques such as computer aided design (CAD) and computer aided manufacturing (CAM) along with computer controlled manufacturing equipment are being incorporated into the development of computer integrated manufacturing systems. These systems employ computer assisted design and control from the initial order to final product delivery. Operations throughout the manufacturing enterprise from product design, to parts fabrication and assembly, to product delivery are being organized, scheduled, and controlled by computers. Although these concepts are at the leading edge of technology, they are already being implemented by some of our larger manufacturing concerns.

While the large corporations in this country have the research and development base and the investment capital to design and install advanced manufacturing procedures for their industries, there are many small industries that cannot afford the investment unless they can assess beforehand how the advanced technology might work in their particular industry and whether it will provide a satisfactory return on investment. The proposed Advanced Manufacturing Technology Centers will have the capability to develop prototype manufacturing systems of specific applications in these smaller industries and to allow evaluation of the advanced technological procedures in the improvement of productivity and efficiency. In summary, the centers will allow the small industry to understand the new technology and evaluate the appropriateness of the technology before investing in and installing an automated process. These centers would be especially important in the Southeast where the number of relatively small manufacturing operations is particularly large. The ultimate survival of these smaller industries, which collectively form the backbone of America's industrial strength, may well depend on the speed with which CAD/CAM technologies are employed. The new technology should allow existing industries in states such as Alabama to improve their competitive positions in the world market. This is important because, in my opinion, the renewal of our existing industries rather than the influx of new industries will be the primary bases for economic recovery in Alabama. Regionally this fact is supported by a recent report from the State of Georgia that most of the new jobs within that state came from the expansion of companies already in the state.

There are precedents for centers to provide prototypes to assist industries in evaluating advanced manufacturing techniques. The Japanese Company, NEC, Ltd., has established a plant to evaluate advanced manufacturing methods for new products before going to production. George Devol, the developer of industrial robots, proposes to develop the most automated plant in the world and rent it to manufacturers. A group of manufacturers in conjunction with a university has established an automation center to allow potential users to gain experience in solving manufacturing problems. And West Germany established a test facility for robots at a university.

As indicated above, there is some activity in the United States. Generally, however, it is less intense and lacks the coordinated contributions that S. 1286 affords. As an example, Purdue University is developing on its campus a laboratory that is essentially an automated factory. There is a need much closer to home. Alabama is one of the leading manufacturing states in the Southeast. In the primary and fabricated metal industries, it leads all Southeastern States in employment and value added. Recognizing the dependence of the Alabama economy on manufacturing and in keeping with its mission as a land-grant institution, Auburn University is proceeding with the establishment of an Advanced Manufacturing Technology Center. Already we are modifying our educational programs to incorporate such technologies as CAD/CAM and robotics. We are performing research in advanced manufacturing technology areas, and we have assisted industry in the application of the technology.

We need to do more. We need to accelerate the technology transfer, the application of this advanced technology, particularly within our smaller industries. To accomplish this we must develop prototype manufacturing systems for industrial application. By being able to demonstrate and evaluate these advanced manufacturing technologies in specific applications, we believe that we can substantially accelerate the application of these techniques. We are hopeful that funds for the initial development of this capability can be obtained through legislation such as S. 1686. We are confident that once this capability is developed we will be able, by successful application, to attract the industrial support necessary to sustain the operation of the center.

The regional Advanced Manufacturing Technology Centers offer an excellent opportunity for cooperation among industries, government, and universities. It is a team effort: Government can provide the initial development capital through legislation such as S. 1286 (although the level of funding for the cooperative agreements would probably need to be increased), universities can operate the centers, and industries can support and expand the centers through sustaining memberships and user fees.

I urgently request that the Committee on Commerce, Science, and Transportation give serious consideration to the establishment of the proposed Advanced Manufacturing Technology Centers at appropriate universities in the Committee's further exploration of ways to promote technological innovaton through cooperation among industries, government, and universities.

Senator HEFLIN. We are pleased that Dr. James Woodward, dean of the school of engineering at UAB is with us. Dr. Woodward, we are delighted to hear from you.

Dr. WOODWARD. Thank you, Senator.

It is always exciting to be the last speaker on a panel, particularly on a full day of testimony. What you expect is that all of your points will have been made at least once before you speak, and my expectations have been met today. But perhaps I can give you a different context for some of the points that have been made.

Certainly, it has been confirmed today that there is general acceptance of the assumption that to successfully compete in the world marketplace, we have to develop new technologies and we have to successfully implement those technologies. This effort will require collaboration of industry, labor, education and Government. Indeed, the principal purpose of this hearing is to look at ways for the Federal Goverment to provide assistance.

For example, S. 1286 is intended to support research and development and implementation of new manufacturing technologies. Will this bill, if passed, actually achieve its purpose?

I certainly think the programs included in the bill would be helpful and would be very important, but I think the overall impact might not be as much or as great as is intended by these sponsors. It is my view that many of the Federal initiatives have been too narrowly defined and too narrowly administered. Certain very important categories of economic activity have either been ignored or given inadequate attention.

In order for an industrial firm to successfully bring a new technology to bear on the marketplace, three fairly distinct steps have to take place. First, there has to be the development of the technology. Second, there has to be the implementation of the technology; and third, there has to be modification to the infrastructure that is needed to support the utilization of that technology. Let me spend a few minutes discussing each of these three steps.

The first step is the actual development of the technology. Now, this is the area of activity where you frequently hear terms such as "high tech" and "advanced tech," et cetera. Many Federal initiatives aimed at economic development are focused on this area, the development of new technology. While this is certainly an area of major importance, the reason for its importance is often misunderstood.

High tech industries will not create a huge number of jobs. In 1979, only 3 percent of the employment in the nonagricultural sector worked in industries classified as high tech by the Bureau of Labor statistics. That number will only grow to about 4 percent by 1993.

But these industries are critically important to the economic health of the country. They are the "tool makers" of the future. Most other industries will be "tool users."

This leads to the second step required for successful implementation of new technology, again, in the marketplace. That step involved the interface between the "tool makers" and the "tool users." It is a difficult area of work and one where this country has inadequate expertise. Success requires an understanding of the capabilities of the new high tech products.

It also requires the understanding of the needs of the user firms. The availability of new technologies has far outstripped their utilization in this country. Major improvements in manufacturing productivity, for example, could be made immediately with widespread implementation of existing manufacturing technologies.

The last step in the process is one which is too frequently overlooked. A high tech product such as a robot, say, placed on a production line cannot be successfully operated without modifications being made to the surrounding infrastructure.

For example, are the workers trained and prepared to use the new technology? Do the product designers know how to design new products which use the capabilities of this new technology? Is the sales force prepared to market the new products? Will the internal accounting and management control systems have to be modified because of this new technology?

Perhaps the best discussion I have seen on the impact of new technology on the way we do business is in the November–December 1983 issue of the Harvard Business Review in an article entitled "Plan for Economics of Scope."

Let me read an extract from that article, and I quote:

> Of late, business press and management seminars have been alive with the promise that leading-edge production technology will restore the competitive cost position of American industry. Less well appreciated, however, are the far-reaching effects that such process advances will have on the underlying structure of management operations. Heightened flexibility, shorter production runs, more customized products, faster response to changes in market demand, greater control, and accuracy of processes, quicker through put—all of these and more will inevitably result if—if managers apply the new technology well. The "if" is, indeed, the hub of the problem, for successful application here means unlearning a host of familiar . . . assumptions.

The article also argues that the past has been the purview of large companies with narrow production lines which maintained cost competitiveness through economies of scale. The future will be smaller companies with broad lines of products which maintain cost competitiveness through the use of new technology to achieve "economies of scope" rather than economies of scale.

The article also points out that we need to stop thinking about successful world competition being limited to large industrial firms. The new technologies will drastically enhance the capabilities of small firms to compete in the international marketplace.

In looking at Federal programs, perhaps a useful first step would be to ask where these programs are located in a simple two-dimensional matrix. The vertical axis of the matrix can be broken into three categories: development of technology, implementation of technology, and modification of the infrastructure.

The horizontal axis can be related to the size of the industry or firm. For the sake of simplicity here, let me separate that axis into only two divisions: large firms and small firms. As you will see from the figure that is at the end of the paper I have handed to the staff, this subdivides the "business universe" into only six categories.

You can actually consider each of these categories and ask yourself what the potential impact of the program or Federal bill will be. In my opinion, most Federal programs are skewed toward development rather than implementation, and large industry rather than small industry.

Let me give you a concrete example of the type of firm which will probably not be helped by this bill, and as best I can tell there is no Federal assistance that would help this particular type of company. A couple of weeks ago I visited a small manufacturing firm which uses wire to produce wire products such as chains, clotheslines, small garden tools.

The company has 30 to 35 employees, and annual sales something in the excess of $1 million. The president of that firm indicates that he faces foreign competition, usually Japanese, on all contracts on which he bids.

He recently won a substantial Federal contract but only because the Federal agency places a 50 percent cost penalty or price penalty on foreign competitors.

After reviewing that company it was our opinion that the company has excellent marketing. It has excellent personnel management, excellent production management, excellent fiscal management, but the production facilities were not excellent. In many instances they were archaic.

The company's productivity could be greatly enhanced by the utilization of existing technology. Most of the applications needed are fairly straightforward. That is, their need is the implementation of existing technology, not the development of new technology.

This situation is probably repeated in 50 to 100 small manufacturing firms in and around the Birmingham region, and I am sure that it is repeated in many of thousands of small manufacturing firms throughout this country.

Now, assuming Federal support were available to work at this interface, universities in the country could play a major role, as Dr. Parks has indicated. Indeed, there appears to be no alternate.

The new technologies have developed too quickly for there to be broad knowledge about their capabilities within industry. To a large degree, that knowledge is focused within universities. Further, that knowledge could be shared without a great deal of expense.

With an annual operating budget of say $250,000 to $350,000, UAB could establish something called a "Center for the Implementation of Manufacturing Technologies" which we think could serve the small to medium manufacturing firms in Birmingham.

If similar centers were formed in the largest 100 cities in the country, the total cost would be about the same as the grant program proposed in the S. 1286. Although at a much smaller scale, these centers would serve manufacturing in much the same way that the agricultural extension service has served farming for many years. I do not need to point out how successful our agricultural products still are in the world marketplace.

I would like to close my remarks by reemphasizing my believe that the Congress is not giving adequate attention to the implementation of the new technologies. Most Federal initiatives continue to be too narrowly focused on the development of those technologies.

Serious consideration should, in my opinion, be given to the concept of a "technology extension service" modeled after the highly successful agricultural extension service.

Thank you, Senator.

[The statement follows:]

STATEMENT OF J. H. WOODWARD, DEAN, SCHOOL OF ENGINEERING, DIRECTOR, CENTER FOR INDUSTRIAL AND APPLIED RESEARCH, UNIVERSITY OF ALABAMA IN BIRMINGHAM

It is now apparent to all sectors of society that this country must develop and successfully implement new technologies if we are to compete effectively in the world market place. The achieving of this goal requires cooperation by industry, labor, education, and government. Indeed, the principal purpose of this hearing is to identify ways for the federal government to assist. For example, Senate bill 1286 is intended to support research, development, and implementation of new manufacturing technologies. Will this bill, if passed, achieve its purpose? I think the programs included in the bill would indeed be helpful, but the overall impact might not be as great as intended by the sponsors.

In my opinion, many of the federal initiatives have been too narrowly defined or too narrowly administered. Certain very important categories of economic activity have either been ignored or have been given inadequate attention.

In order for an industrial firm to successfully bring a new technology to bear on the market place, three fairly distinct steps must be taken: Development of the technology; implementation of the technology; and modification to the infrastructure needed to support the utilization of that technology.

Let me spend a few minutes discussing each of these steps.

The first step is the actual development of the new technology. This is the area of activity where you frequently hear terms such as "high tech" and "advanced technology." Many federal initiatives aimed at economic development are focused on this area, the development of new technology. While this is certainly an area of major importance, the reason for its importance is often misunderstood. High tech industries will not create a huge number of jobs. In 1979, only 3 percent of the employment in the non-agricultural sector was in industries classified as "high tech" by the Bureau of Labor Statistics. This will grow to only 4 percent by 1993. But, these industries are critically important to the economic health of the country. They are the "tool makers" of the future. Most other industries will be "tool users."

This leads to the second step required for the successful implementaton of a new technology in the market place. That step involves working at the interface between the "tool makers" and the "tool users." It is a difficult area of work and one where this country has inadequate expertise. Success requires understanding the capabilities of the high tech products and understanding the needs of the user firms. The availability of new technologies has far outstripped their utilization. Major improvements in manufacturing productivity, for example, could be made immediately with the widespread implementation of existing manufacturing technologies.

The last step in the process is one which is too frequently overlooked. A high tech product such as a robot placed on a production line cannot be successfully operated without modifications being made to the surrounding infrastructure. For example, are the workers trained and prepared to use the new technology? Do the product designers know how to design new products which use the capabilities of the new technology? Is the sales force prepared to market the new products? Will the internal accounting and management control systems have to be modified because of the new technology?

Perhaps the best discussion I've see on the impact of the new technolgies on the way we do business is in the November-December, 1983 issue of the Harvard Business Review in an article entitled "Plan for Economies of Scope" by Joel Goldhar and Mariann Jelinek. Let me read an extract from the article:

"Of late, business press and management seminars have been alive with the promise that leading-edge production technology will restore the competitive cost position of American industry. Less well appreciated, however, are the far-reaching effects that such process advances will have on the underlying structure of management operations. Heightened flexibility, shorter production runs, more customized products, faster response to changes in market demand, greater control, and accuracy of processes, quicker through put-all of these and more will inevitably result if managers apply the new technology well. The "if" is, indeed, the nub of the problem, for successful application here means unlearning a host of familiar . . . assumptions."

They argue that the past has been the purview of large companies with narrow product lines which maintained cost competitiveness through economies of scale. The future will be smaller companies with a broad line of products which maintain cost competitiveness through using new technology to achieve "economies of scope."

This article also points out that we must stop thinking about successful world competition being limited to large industrial firms. The new technologies will drastically enhance the capabilities of small firms to compete.

Perhaps a useful first step in considering federal programs aimed at economic development is to first ask where those programs are located in a simple two-dimensional matrix. The vertical axis can be separated into three categories: development of technology, implementation of technology, and modification of infrastructure. The horizontal axis is related to size of industry or firm. For the sake of simplicity, let me separate that axis into only two divisions: large companies and small companies. As you will see from the figure at the end of the paper I handed you, this sub-divides the "business universe" into only six categories. The numbers in the matrix indicate my, admittedly crude, evaluation of the likely impact of Senate bill 1286. The scale varies from 1 to 10 with 10 indicating the greatest impact. As shown, I think this bill stresses the development of new technologies by large industry and the utilization of new technologies by large industryu. Although these are perfectly legitimate goals, I am concerned because most federal initiatives seem to be skewed toward "development' rather than "implementation" and toward "large industry' rather than "small industry."

Let me give you a concrete example of the type of firm which will probably not be helped by this bill. A couple of weeks ago I visited a small manufacturing firm which uses wire as the raw material and produces wire products such as chain, clothesline, and various garden tools. The company employs 30 to 35 people and has sales of $1,000,000 to $2,000,000 annually. The president of the company indicated that he faces foreign competition, usually Japanese, on all contracts on which he bids. He recently won a substantial federal contract, buy only because the federal agency places a 50% price penalty on foreign competitors.

It was our opinion that the company has excellent marketing, excellent personnel management, excellent production management, and excellent fiscal management. However, the production facilities were not excellent. Certain portions might even be classified as poor.

This company's productivity can be greatly enhanced by the utilization of some existing technologies. Most of the applications needed are fairly simple. That is, their need is the implementation of existing technology, not the development of new technology. This situation is probably repeated by 50 to 100 small manufacturing firms in the Birmingham region and by thousands of similarly sized firms throughout the country. Yet, in my opinion, there does not seem to be a single federal program which will provide assistance.

Assuming federal support were available, the universities in this country could play a major role in filling this void. Indeed, there appears to be no alternate. The new technologies have developed too quickly for there to be broad knowledge about their capabilities within industry. To a large degree, that knowledge is focused within universities. Further, that knowledge could be shared without a great deal of expense. With an annual operation budget of $250,000 to $350,000, UAB could establish a Center for the Implementations of Manufacturing Technologies which could properly serve the small to medium manufacturing firms in the Birmingham region.

If similar centers were formed in the largest 100 cities in the country, the total cost would be about the same as the grant program proposed in Senate bill 1286. Although at a much smaller scale, these centers would serve manufacturing in much the same way the agricultural extension service has aided farming. I am sure I do not need to point out that farming is one area where this county is dominant in the world market place.

I will close my remarks by re-emphasizing my belief that the Congress is not giving enough attention to the implementation of new technologies. Most federal initiatives continue to be too narrowly focused on the development of these new technologies. Serious consideration should be given to the concept of a "technology extension service" modeled after the highly successful agricultural extension service.

Development of technology:	
Large firms	10
Small firms	2
Implementation of technology:	
Large firms	5
Small firms	1
Modification of infrastructure:	
Large firms	2
Small firms	1

Senator **Heflin**. Well, thank you, gentlemen. We appreciate your very thoughtful and thought provoking testimony. I thought the testimony from each of you was excellent.

I know that there is some cooperation existing between universities. For example, I know at UAB and Auburn you have some relationships on some nutrition problems.

Would you all care to explain what you are doing there just to give us some ideas of how the two universities have cooperated because in some of the aspects it does call for joint university cooperation, and in this you have got a nutrition type of program going on in genetic engineering as I understand it. Maybe you could explain it a little bit.

Dr. **Parks**. Let me make a few comments. As you know, the University of Alabama, Birmingham through its medical school has for some years developed a very fine faculty and research program in the area of molecular genetics or genetic engineering primarily related to medical sciences.

Auburn has committed some of its resources, a considerable amount of its resources, to develop the area of molecular genetics as it relates to agricultural production, primarily, improvement of plant species, improvement of the way plants react to certain environmental stresses, improvement of certain animal performance characteristics, the production of vaccines, this sort of thing.

It occurred, I think, to Dr. Glaze and myself early on that this is an area that was a natural for cooperation between the two universities because of their basic knowledge in this field and Auburn's commitment to develop the more applied areas of molecular genetics. That has led to a series of meetings between our faculties.

I believe there is another meeting on the 12th of this month with Bob to continue these discussions. We are anticipating submitting perhaps some joint proposals for funding so we are very much encouraged, Senator, about this kind of cooperative action.

If I might make one other point, we have a similar interest in working with the university system, University of Alabama system, in this area of advanced manufacturing technology; that is, developing some cooperative efforts in those areas as well. So both of these areas we are going to try to cooperate on.

Dr. **Glaze**. I would just add that particularly in both research and education areas there has been several areas of longstanding collaboration between Auburn and UAB. The pharmacy school at Auburn does not have readily available to it intern experiences for their pharmacy students in how to handle the pharmacy in a large hospital which is a very complicated and somewhat different situation.

So for many years there has been a program where they send their faculty and students, and as a matter of fact I find in my parking place almost every morning an Auburn car which has brought a carload of students up as part of our pharmacy program or one of the other areas.

In a similar vein, we have a very close collaboration with the veterinary medicine school. We have on our staff most of the expertise in the State of Alabama either on our staff or at Southern Research in laboratory animal medicine, which is a very speciaized area dealing with the mice and rats and other animals which are used for experimentation in laboratories. Our faculty teach that part of curriculum in veterinary medicine in Auburn, and there is an exchange in fellows of personnel there of longstanding.

Finally, we have a "Project HELP" which has been going on a long time. It was developed originally under Appalachia Regional Commission funding to do health testing in rural areas, and this has been a collaborative project between first our medical school, now school of public health, and the cooperative extension service in Auburn. I guess that has been going on almost 15 years.

Dr. **Parks**. More or less.

Dr. **GLAZE**. So there have been a longstanding series of collaborations at Auburn. There are many others we can talk about, but I believe these are all areas in which we have worked.

We would hope the development of the research park and collaborative research efforts would augment and extend this kind of relationship.

Senator **HEFLIN**. I did not know until today that Auburn takes the veterinary students from the University of Kentucky, and that there is an appropriation made from the Kentucky Legislature to Auburn to train the veterinary students from the University of Kentucky. That is a big horse country so they send——

Dr. **PARKS**. Senator, at one time there was a regional compact that Auburn took students from some four or five States, but as these other States have built their own schools of veterinary medicine we are now down to just the relationship between Alabama and Kentucky, but that is right. We do take those students.

Senator **HEFLIN**. Well, that was interesting. I found that out today.

Dean Woodward, I was talking with Mr. Hardin of Rust Engineering relative to the cooperation between industry in the engineering field and the university here, and Dr. Portera and Dr. Parks, you all might comment on this.

I know between Auburn there are some type of various projects going on with TVA, and if you would in the engineering field and industry the type of cooperative efforts that are presently being conducted.

Dr. **WOODWARD**. Yes, sir.

Most engineering research is skewed toward the applied end of the spectrum. Therefore, it is reasonable for marketable products to come from engineering research. So of those disciplines within a university, it is common to find schools or colleges of engineering having a very close relationship with industry. We do indeed do that.

To pick up on the biomedical engineering, which is one of the more productive disciplines within our school of engineering, we are working with companies outside the United States; outside the Brimingham area, and within the Birmingham region to develop new medical devices and products that will be used in the health care industry. These are very active types of collaboration.

With the local community, Birmingham does have a large number of consulting engineering companies. The school of engineering here views one of its principle responsibilities the support of consulting engineering. As Mr. Hardin indicated, we are, I think, the only school in the Southeast now that teaches something called process instrumentation within its electrical engineering program.

Process instrumentation focuses on the utilization of computer devices and other instrumentation to control industrial processes. Let me take 1 minute and tell about a specific instance.

The new United States Steel pipe plant here—I think the related cost was in the neighborhood of some $20 million to $25 million—was designed to utilized computer-based process control devices. The design for that was done by Rust Engineering.

It turned out that the people responsible for running the mill or plant did not know anything about those devices. They had never had any experience with them within United States Steel. They came to UAB and asked us to teach their people how to use these things.

Two years ago we had 40 United States Steel people on campus for 3 weeks. These were technical people. These were baccalaureate, professional level people.

We taught that course for them. This year we taught a similar course for another group of technical people, and then a group of management people from United States Steel in Pittsburgh came down and spent 2 weeks with us.

There we were trying to teach them how to use this new technology in their particular industry, and not just the technical people, but the people that have to manage the industries.

Dr. **Parks**. Since you mentioned TVA, Senator, I will simply point out that Auburn has worked very closely with TVA over the last several years in the cooperative effort to develop procedures for the conversion of waste hardwood into liquid fuel. That has been an area of very active cooperation between Auburn and the TVA.

Another area we have corroborated with industry also reflects I think what we were talking about here today, that of Government-industrial-university cooperation. That has been our work with Air Product Corp. with City Services, and this work was supported by DOE and had to do with the conversion of coal to liquid fuels or to low-sulfur products so we have experience in a number of areas. This is two, just two examples of that kind of cooperation.

Dr. **Portera**. I think the same is true for the university. We do not do enough of it.

Our activities range from cooperating with industry securities to basically taking over a factory and running a factory. It is pretty substantial, but we do not do enough of that.

Senator **Heflin**. Dr. Glaze, you intrigued me with your idea of a provision in the bill that would allow for a cross-working at other institutions. In thinking about it, it may well be that in certain areas there could be centers in which there could be extended seminars and extended cross-fertilization of idea gathering.

I know that in all professional groups that gather good minds in the field interchange is good. Sometimes they turn out to be drinking bouts, but nevertheless there is a lot of exchange, a lot of good ideas.

Most of the time the seminars are pretty short and they do not do it. They are usually held at some type of resort, and they get to be rather expensive and the financing agency—they are all looking for the Hilton Heads and the Point Clears and the Greenbriers and all that sort of thing, which I am not so sure that in the long run that is the best place overall to do it.

There are too many diversions from what their main purpose is. I think you have to have some recreation, but added to our idea of having some type of a partial funding by the Federal Government for exchanging of people in certain institutions that are carrying on appear to me that would have a lot of merit to it.

Dr. **Glaze**. I think there are a number of experiences that can be as short as a month or 2 or 3, all the way up to a year long stay by people either in industrial laboratories or universities depending on where they are coming from. I think this is particularly important in view of something else I said which is namely, the rapidly moving frontier of technology.

The traditional ways, in which universities transferred their knowledge to industry, are: The faculty consults for brief periods, usually several days at a time in industry; and our graduates out of our baccalaureate and graduate programs move into industry.

The former that is still working is a very effective way of consulting, but with the technology moving so fast industry cannot acquire people fast enough in most of these areas. So I think there needs to be some things to move people who have got the basic smarts and the basic training in the field into the university to learn some things, and also, we need to have some exchange going the other way to make these collaborations really work because they have to be one on one collaborations to really be effective.

Senator **Heflin**. I would like to ask the two gentlemen in research parks to give their thoughts on the needs on future education and new technologies, not only at the labor force and the skilled labor force but also at the professional and advanced degree level.

I do not know whether you were here when they testified but basically there are people that are quite worried that we are going to enter into an era of rapid change and what may be the latest thing 5 years from now, 10 years from now may be out of date, and that we may have to redo a lot of retraining.

Some expressed it as retraining almost every 10 years, and that there may need to be more requirements of formalized advanced education. I just wondered if you all have any thoughts relative to this. I will start with you, Dr. Portera, if you do.

Dr. **Portera**. Obviously, I think the statement that you are making is a very accurate one. I think that most institutions in the country—I know the ones in Alabama—recognize and are attempting to provide a response to the need for effective continuing education programs.

We all here are very much committed to providing the kinds of continuing training that graudates of institutions need. You are certainly right that by the time the graduates are out in the field for 2 or 3 years their skills need to be upgraded, and our continuing education programs are designed hopefully to provide some of that. I think we have got tremendous improvements to make in those areas though, and I think most of us are pretty busy at this time trying to respond to that.

A second area that I would mention that we all have work to do in, and I think you see that we are attempting to respond in the area, is what Bob Glaze mentioned a few minutes ago about management in a technological environment and technological society. There is much more in the way of interdisciplinary work that you see these universities doing these days.

Bob mentioned that. I believe you said your management program and your school of engineering are located in the same building now.

You are going to see more of location, not only close geographic location with one another, but there is going to be more and more in the way of cooperation between schools and programs in engineering and in management commerce, obviously because managers in the future will need the kind of technical training that many engineers are getting and the converse of that, engineers are going to need management skills and there will be a lot more in the way of cooperation there and that is an area where you will see a tremendous amount of emphasis, in my opinion, in institutions. That is, interdisciplinary work with one another.

The final thing that I would mention, though, having received a liberal arts education is that our technical people are going to need their course work in the areas of liberal arts and humanities and you see institutions doing things like ours in this State, creating core curriculum for their students and trying to place emphasis in those areas for people who are being trained in a technical degree.

Dr. Glaze. I will just emphasize what Mack has said. I think this is something all of our faculties are struggling with, how, in an increasing technical society, do we provide our graduates with an understanding of what they do not know as much as what they do know.

Someone said it to me rather dramatically the other day, "That we do our job best if our graduates realize how ignorant they are when they graudate from our institution so that they are committed to continuing to learn the rest of their lives.

No longer is a college or even a graduate education a completion of your education. It gives you an understanding of how much more you have to learn, and this is particularly true these days.

The crux of it is that we have got to have broadly educated people. The technical personnel in our industries and in our technical and scientific programs have got to be broadly educated in the humanities.

Like Mack, my background although I am a trained scientist is in the liberal arts tradition, and the most valuable thing I learned to do was to read and write very well in college, I think this is something we need to do a better job of in all of our institutions.

Dr. Parks. Senator, we not only agree that that is a major problem you have posed, but we are deeply concerned about it. I believe Dean Woodward would agree that in an area like microelectronics, today the student is hardly out of the door before the field begins to change on him.

Our dean of engineering is in the process right now of developing an extensive outreach program to give us an opportunity to reach on a regular basis into the industries in the State for training, retraining, and opportunities for graduate work to put in place some kind of continuing network that will allow us to offer this kind of continuing education. If we do not do this we are simply going to put our industries and our graduates in a position where they cannot compete in the field they are in. It is just that simple. So we certainly agree with the problem raised.

Dr. Woodward. The pressures on universities are unusual now. It creates a lot of excitement. It creates a lot of problems.

We are being drawn closer to the segment of society that we have been fairly distant from in the past, and we are accepting that grudgingly and with some considerable care. We hear a great deal of talk about the impact of industry demands on basic research, and there is a lot of legitimate fear about that type of thing.

Universities such as the ones represented here talk a great deal about it within their own boundaries, and given this new responsibility how shall we carry it out, but yet not forget perhaps a longer term commitment and obligation on behalf of an institution.

I do believe that people have to be retrained, but I do believe that even in an engineering curriculum there are certain things taught that will not change. Engineering curriculum is built very strongly on the basic sciences and mathematics.

The next level is what is called engineering science, and it is only in the last year or last year and a half you teach students how to do design based on those principles. It is the design practices and tools that you use to do design that change quickly.

It is not the basic training that the students get. Now, part of that basic training is in the humanities and arts. I think it is an exciting time for universities, and we are trying to learn to respond, and I think we have done a fairly good job.

I think we are doing a fairly good job in this state. Continuing education is one that we will have to do more of in this State.

Certainly, the engineering schools know that. The UAB School of Engineering had 1,500 students that came to programs in engineering continuing education last year at UAB, and we expect to do more of that. Again, it is an exciting time for all of us.

Senator **HEFLIN**. Well, thank you.

If you have any further ideas of anything including this last idea as to how the Federal Government might play a role in meeting the challenges of the educational needs of the future—I think it ought to be primarily a State function but it could well be tied into some type of a center, regional or possibly State that there could be a role at least for some seed money.

Well, thank you. We think the hearings have been very helpful to us and we appreciate everybody's participation.

We stand adjourned.

[Whereupon, at 3:30 p.m., the subcommittee was adjourned, subject to the call of the Chair.]

ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

WEDNESDAY, DECEMBER 7, 1983

U.S. Senate,
Committee on Commerce, Science, and
Committee on Commerce, Science, and Transportation,
Huntsville, Ala.

The subcommittee met, pursuant to notice, at 9:30 a.m., at City Hall, Huntsville, Ala., Hon. Howell Heflin (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR HEFLIN

Senator Heflin. Today we continue hearings in Alabama on the role of research and technology in stimulating the economy and U.S. industrial competitiveness. This hearing is being held by the Senate Subcommittee on Science, Technology, and Space, where I serve as the ranking Democrat.

I cannot think of a more timely topic for Alabama or the country as a whole. There is still a major unemployment problem, and we need to find ways to get people working again—in productive jobs. We need to have our schools and universities provide an opportunity for our young people to learn the skills they will need in those jobs. We need to keep our industries competitive in tomorrow's increasingly competitive world marketplace. And, we need to figure out how the Government can work with industry and our schools in a cooperative fashion.

There are many ideas and proposals floating around in Washington about what we must accomplish to get the U.S. economy in better shape. The States and cities, business enterprises, labor, and universities are all trying to map out strategies to revitalize our basic industries as well as take advantage of the developing high technologies.

We will have to invest in those new technologies that will keep us competitive, technologies in such basic areas as manufacturing, as well as frontier areas such as space, lasers, electronics, computers, biotechnology, and many others. I believe that whatever strategies we develop we will have to rely more on cooperative efforts among Government, industry, universities, and labor.

This hearing will continue to gather information and ideas that should be helpful to the committee in its deliberations. We are considering a bill, S. 1286, the Manufacturing Sciences and Technology Research and Development Act of 1983, introduced by Senator

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Slade Gorton, the chairman of our subcommittee, and which I cosponsored. We have held 4 days of hearings already, and the hearings in Huntsville on university-industry-Government cooperation will be particularly valuable.

I look forward with a great deal of interest to hearing what our distinguished group of witnesses will have to say. We welcome General Bunyard and Mr. Joseph Moquin. General Bunyard, if you would, if you please would start.

STATEMENT OF MAJ. GEN. JERRY MAX BUNYARD, COMMANDER, U.S. ARMY MISSILE COMMAND AND REDSTONE ARSENAL

General **Bunyard**. Good morning, Mr. Chairman.

I am Maj. Gen. Jerry Max Bunyard, Commander of the U.S. Army Missile Command and Redstone Arsenal, and we too welcome the opportunity to appear before this hearing this morning.

Now, your staff suggested that when we were preparing for this testimony that I briefly trace the evolving relationship between the Army and our civilian neighbors in north Alabama. It is a special and perhaps a unique situation, partnership of mutual understanding and support. Certainly in my some 29 years of experience I have not found elsewhere the sense of common purpose that unites the military and civilian community that I find here.

Now, the Army came to what came to be known as Redstone Arsenal some 42 years ago, a few months before the United States became involved in World War II, to establish and operate an arsenal for the manufacture of chemical munitions.

Now, good things have resulted from that decision, for the Army, for north Alabama, for the United States, and for the free world.

Today, the many operations based here to execute the Army missile program are a direct result of that decision that first brought the soldiers here in 1941. And so are the operations of the Marshall Space Flight Center, created in place in 1960 from a nucleus of buildings, equipment, and skilled people that were transferred from the Army missile team. And so too are the people and the mission of the Army Ballistic Missile Defense Systems Command, which was a second major spinoff from the original Army missile team.

The diverse high technology missions of the Federal agencies here helped to stimulate the economic growth throughout north Alabama. And I think it is fair to say that had it not been for the Federal activities that brought thousands of people and billions of dollars in wages, contracts, and aid here in the last four decades, Huntsville, Madison County, and north Alabama would at least be different than what they are today.

Documents in our files show that the Army chose to locate here in 1941 because good and abundant land could be had at a reasonable price; because of the transportation facilities already in place, and because of the readily available electrical power, raw materials, and fuel. Health, climate, and living conditions were rated excellent by the Army survey team. Finally, and very important, they reported a large work force could be hired locally—and here I quote directly from the survey report—from "a population considered loyal and willing."

And so they have proved to be through the years.

Now, those are the reasons that the Army documented for coming here in preference to sites examined in six other States and two others within Alabama. And I suspect that there were other reasons too, Mr. Chairman, but I will have to refer you for those to the Honorable John Sparkman, who served this district ably then as a Member of the House of Representatives and for many years thereafter in the U.S. Senate.

Certainly one of the major explanations for the good things that have happened here is the wise and watchful leadership provided by the Alabama congressional delegation which continues to this great day.

The military operations here almost certainly would have shut down and disappeared eventually after the end of World War II, as they did in so many locations elsewhere in the Nation, had it not been for the Army decision in 1948 to centralize at Redstone Arsenal its then beginning missile and rocket operations.

Again, documents in our files show even then that the Army believed synergistic benefits would eventually result from siting in a single location its total mission, the people responsible for executing it and the necessary laboratories, test ranges, and specialized facilities.

In that belief, the Army soon moved Thiokol and Rohn and Haas, two industries considered critical to the success of the rocket effort, into the Government buildings on the arsenal. Soon thereafter, the Army established a school on the installation to train soldiers in this new technology.

In time, local industry evolved and successfully competed for a share of the Army missile contracts.

Indeed, the gradual evolution of this area of north Alabama in general, and Huntsville in particular, into an economy centered on high technology excellence. I believe this can be traced to that Army decision more than three decades ago.

I believe, too, that the men who made that decision then, if they could be with us today, they would be amazed at how far those synergistic effects they hoped for have exceeded their expectations.

Now, with that background, let me point out now that the reasons that brought the Army here are not the reasons that keep us here.

The high-tech work of the Army today, the Marshall Center and much of the industry that has grown here in the past decade requires diverse skills of a much higher order than the manufacturing operations the Army ran here during World War II by offering on the job training to an unskilled labor force.

Success in our business today, whether the goal is the national defense of the United States, manned operations in space, or making a profit in an intensely competitive industry, depends almost entirely on the quality of the people who do the work and their ability to develop, understand, and apply a technology that moves forward so rapidly that we all use and understand the phrase "technology explosion."

To succeed today, the Army, NASA, and locally based industry must attract and keep top quality men and women. The technical challenge of our work and the pay and benefits that we offered once were enough. However, that is no longer the case.

All of us now must look to the community, to the leadership, and its institutions, most particularly to the educational institutions, to create the environment we must have to attract and keep the people we need.

We especially need strong local institutions of higher education. It is no accident, for example, that the University of Alabama in Huntsville traces its beginning to graduate level engineering classes taught in Army barracks on Redstone Arsenal three decades ago.

Now, others may differ with me on what I say next, but in my judgment we look to our local colleges, universities, and technical schools to do three things:

First, we want them to provide advanced training for people already in our work force to keep them current on the latest developments and techniques.

Second, give us graduates with the skills and educational background to qualify for places in our work force.

And three, to do research for us within their capabilities.

In brief, the leadership of the high technology industry here must look to the community and its leaders to do those things for us which we cannot do ourselves.

In my judgment, the community has been equal to that challenge. They not only met it, but they excelled in meeting it. The leadership here, and I mean to include all elements of the community, have acted with energy and imagination. They have worked with us with understanding, cooperation, and trust as partners and friends.

The local civilian leaders over the years have done far more than help us. They have made us believe that we are an integral part of their community; and that is something we soldiers value greatly.

In summary, Mr. Chairman, the records show the Army and this community have worked well together for four decades, I believe to our mutual benefit. For our part, we have attempted to aid the community in every way possible within the bounds of Federal law and policy.

We have kept local leaders advised of any changes in our operation and mission that would affect or impact the community. We have provided our expertise in assisting the community in planning for orderly development and growth. We have, on occasion, assisted the community in obtaining Federal property formerly part of Redstone Arsenal for schools, industry, recreation, and cultural purposes. We have shared, in some instances, Federal assets that could be of use.

A notable example of this is the Redstone Scientific Information Center, jointly operated by the Army and NASA, which houses one of the world's best collections of scientific and technical information, and is available for use by local students and industry.

We have done these things in the belief that what was good for this community was good for the Federal activities based here.

And finally, Mr. Chairman, your invitation to appear today specifically asked for comments that we might have on bill S. 1256, pending legislation that would authorize the Department of Commerce to fund research in advanced manufacturing techniques.

The Department of Defense has had a similar program for many years. The Army Missile Command here at Redstone has participated in the Army's manufacturing methods and technology program since 1965.

The program has worked well for us and real benefits have been obtained. For example, in the past 5 years, 1978 through 1982, my command funded 52 projects at a total cost of $34 million. Thirty-nine of those projects have been implemented with projected savings of $347 million, and that's a savings to investment ratio of 10 to 1.

Mr. Chairman, that completes my comments, and I'll be prepared to answer any questions at this time.

Senator **Heflin**. Thank you. We will go ahead and ask Mr. Moquin if he would go ahead, and ask questions of both of you.

STATEMENT OF JOSEPH C. MOQUIN, PRESIDENT, TELEDYNE BROWN ENGINEERING

Mr. **Moquin**. Senator Heflin, let me also add my welcome to the city. I am going to address my remarks primarily as requested, to the development and history of the research park, and will be prepared to answer any questions that you might have.

I need to bring you back, not as many years as General Bunyard, but to approximately 21 years when it would appear to most people that the city of Huntsville and the county of Madison were postured to see some significant economic growth.

Most of what happened in the initiation of the park was done by Ben Brown Engineering before we became a part of Teledyne. And most of the comments I will make concern what we did in concert with the city and the county.

At that time we felt that we needed to look at expansion and a better location. Now, we approached the city and asked if they would be supportive to zoning an area of the city for a research park, and in considerable more acreage than we needed, to provide a place for high technology industry.

They were more than responsive. And in fact, the city planner at that time and the other people in the city developed a model research park zoning based on the research triangle in the Carolinas.

We then, with that assurance from the city of their support, we then proceeded to look for suitable locations for this research park in the city of Huntsville. We—and I personally made the survey to select the area that we are now located. It had almost all of the desirable attributes for a research park.

It was near one of the main entrances to the Missile Command and the Marshall Space Flight Center. It was at that time attractive land, gently rolling, wooded and available. It could have been and was able to be serviced rather economically. It was near the—what was then only a planned location for the relocation of the Huntsville Airport.

And it had very close to it the only one building that the University of Alabama-Huntsville had at that time; and the UAH, as you may recall, was then moving forward very vigorously on engineering and research programs.

We then proceeded to ask for formal zoning for research park, and I proceeded to option some of the property in that area. We initially optioned approximately 150 acres of what was then our property that we eventually located on, and the Motley Corp. and IBM Corp. We also optioned property in the name of the University of Alabama in Huntsville.

Shortly after the period of optioning and the city moving ahead with their zoning activities, we bought the approximately 150 acres; and then proceeded to ask the city and the county for support in improving the streets, the drainage, the sewers, the utilities and the railroad crossing.

At this point, I want to mention an activity that was agreed upon or a policy that was agreed upon rather informally, but I think it was an important factor in the development of the park.

We felt, the city felt, and I think most of the industry in this area at that time felt that no one should profit from the exploitation of land sales in the research park. This initial establishment of the park did not find the city doing then what it did today, in actually buying property. So two things happened.

One is that industries that located here, such as us, agreed that if we were to sell properties to others it would be sold at cost. We sold a substantial amount of property to Northrup and to IBM, both the commercial arm of IBM and the Federal Systems Division of IBM when they were involved in the Saturn program.

Additionally, at that time the University of Alabama in Huntsville Foundation was established as a land-owning and acquiring arm to acquire land and sell to companies moving into the park, and that any profits from those sales would accrue to the university.

At the time of this initial zoning step, approximately 3,000 acres were zoned research park. I think the history of the development of the east side of the park is well known. The city and county gave considerable help in land preparation.

The streets were vastly improved. As you know, we have an extremely beautiful, wide and properly maintained street in Sparkman Drive. Other streets in the park were built, and all of the utilities and services needed for the development of the park were provided by the city and county; and it grew rapidly during the sixties and during the early seventies.

It was not until 1982 that the real issue of the park west of Ridout Road became apparent to the city and the county. At that time, there had not been any land sales on that side of the Ridout Road, primarily due to the fact that there was no servicing of that area.

One of the property owners, a large property owner on the west side of the park, requested rezoning from research park. This presented the city and the county with a dilemma. The question was: Would there be sufficient need for research park zoned land to deny rezoning requests and to be fair to the property owners. I think you are going to have a presentation of material from Mrs. Spencer later on, and she is very competent to answer any questions in that area better than I; but the stand that the City Planning Commission and others in the city took, City Council took on this issue, I think is very commendable.

Without anything more substantive than the planning activities and the expected growth of the research park in the future, the city held to substantially retaining the research park zone of the property west of the Ridout Road. Some compromise was made, but it was not substantial.

After the rezoning was substantiated, or the rezoning was denied and the research park zone was substantiated, the city then proceeded to acquire it. Now, this was not done on the east side of Ridout Road, but I think it is a major factor to the development of the west side.

There are some 2,200 acres on the west side of Ridout Road. The city purchased 1,818 of these acres at a cost of approximately $3.2 million. Obviously, this is looked upon by the city and by the people of this city as an investment; that as this land is sold in the future, it should recover the cost of those lands, the debt services associated with the purchase of the land, and also the improvement of the land.

I think that an economic analysis of the west side of the park indicated that present value, present sales of acreage on the east side at today's sales price, would be sufficient to recover the land costs, the debt services, and the improvement costs for the west side. And of course, those values will escalate in the future. So I think it is a reasonably safe investment that the city made.

In addition to the purchase of the 1,818 acres or the 2,200 acres, the city has funded two studies at the present time, one for the land use of the west side of the park and the other for a marketing analysis of how Huntsville Research Park is considered competitively with other parks in the Nation.

Both of these studies have been completed within the last few weeks and have been submitted to the city and to other people in the area.

I think, Mr. Chairman, that that will give you a brief history of what happened and how it happened. I would emphasize one point that General Bunyard has made. I do not think that this area would have had the opportunity for the kind of economic growth it has attained, it would not be here today considering the future development of 2,200 acres of development in research park, had it not been for the concentration of Government activities in Huntsville.

Senator **Heflin**. Well, thank you, General. We appreciate your testimony. You indicate that you are going into an expansion area.

General Bunyard, let me—how long was it after the research park was it before—related to the missile development, was it that industry began to come in and to be located in your research park?

General **Bunyard**. Well, sir, I do not have any particular facts on that, but I think it was an evolving situation, where you had some of your prime contractors involved in the missile business, and as they saw opportunities to come to this particular northern Alabama area they came in and started working.

We had other contractors, perhaps that were considered at that point in time subcontractors or those that were not really involved in Government contracts, began to come in here, and consequently started competing for these contracts and were winners in some cases. And competition has been very keen throughout the total missile business, has been in the past, is today and will be in the future.

Senator **Heflin**. Would both of you gentlemen, you first, Mr. Moquin, describe the educational cooperation that has been available to you from the educational institutions in this area?

Mr. **Moquin**. General Bunyard stated those three areas of interest in the educational institutions, and those very accurately describe high technology companies 'interest in education.

I think the first he mentioned and the first I would mention is the availability of graduate work, particularly in the science and engineering fields, to keep our work force up to date on changing and advancing technology.

The second use or important area of support from the universities would be the availability of new graduates in the science and engineering fields and the softwear field.

The third is in the area of research, research support. These areas have always been paramount in the interest of any company existing here today, or new companies moving into the area. And it's extremely important that those availability of—the availability of that type of education has continued to be improved and enhanced for future growth of industry.

Senator **Heflin**. Well, thank you, gentlemen.

Are there certain cooperative arrangements on a more formalized basis? I reckon the costs, use of it by which people in industry and in Government become adjunct professors. And then there is a matter that the educational institutions provide consulting work to the industry and their activities or to the government.

General **Bunyard**. Mr. Chairman, let me provide some facts I think would be an answer to that question. And to carry on where Mr. Moquin was talking about, about 10 percent of our population that we have currently hired at the arsenal are graduates of local universities, Alabama A&M or the University of Alabama in Huntsville; in excess of 750 graduates that are working out there right now.

We have a lot of different students from both universities and other universities locally that are used in the summer programs, and all these other types of activities that we have going on at this point in time.

More specifically, we have our employees curently employed by the Government that are very deeply involved in the various university committees. And I could list considerable numbers of individuals that are involved in that. And consequently, on the reverse, we have the involvement of the professors at the university that are working with us as well. We have worked very closely with Dr. Wright, Dr. Morrison, and some of the other professors at the colleges that we have around here.

We spend right now at least in excess of $170,000 a year for the Army employees to attend the universities that we have here locally. There is a very close working relationship, and it is extremely important that you have these institutions, the academic environment, to be able to further their knowledge in the area that we are in specializing in technology.

And consequently, they are able to go in and help influence, for example, the young students that are going in to college, which avenue that he or she should pursue.

So we are working in that area. There is a lot of things going on. Sone of the facts I hope I have given to you.

Mr. **Moquin**. let me add to that, that there are frequent incidents of cooperation on both sides. Just recently, Dr. Morrison called and wrote me a few times to solicit a specific individual's help, a physicist in our organization, for some high technology work that his school was performing. And we in turn used faculty from UAH and A&M University for some summer employment and for consultation services.

I suspect that we have here in Huntsville one of the largest and best coops, engineering coop programs in the State, both in terms of number and quality and techniques. We supply to many companies in the area and the Government a good many of the teachers for the continuing education activities of the school.

Senator **Heflin**. Well, I am sure that the addition to faculty of some retired people who were world renown scientists when they retired from NASA or some other Government undertaking, that some of the great leaders along with Dr. Werner Von Braun, that then take up a teaching capacity, have added a great deal to the advanced education, particularly in the graduate level.

Well, thank you very much. We appreciate your testimony and are delighted to hear from you.

Our next panel would be Dr. John Wright, president of the University of Alabama in Huntsville; and Dr. Richard Morrison, the president of Alabama A&M.

[Recess.]

Senator **Heflin**. Well, we welcome you gentlemen this morning. Dr. Wright, if you would, we would be delighted for you to start. I understand you have got to get away.

STATEMENT OF DR. JOHN C. WRIGHT, PRESIDENT, UNIVERSITY OF ALABAMA AT HUNTSVILLE

Mr. **Wright**. Yes, sir, I do. I have to go to Tuscaloosa for a meeting in a little bit.

But the first point I would like to make is that what is happening is not a fad, it is a trend. It is an irreversible trend and it represents a deep-seated need as to what is happening in the industry.

The industry, higher education forum that was appointed by President Reagan, I think summarized this issue as well as anyone when they said: "Our society must develop a consensus that industrial competitiveness on a global scale is crucial to our social and economic well being."

So the first point I want to make is that we are dealing with not just a local phenomenon, not just a fad, but a deep-seated need for industry and universities to cooperate. The essential ingredient in the technological innovation process is human resources, and that represents a new factor in economic development in this Nation. The primary resource necessary for the economy to move along is the human resource. It is not a surprise in Huntsville. Von Braun was indicating this to the State some 20 years ago when he indicated that the University of Alabama in Huntsville was needed.

Now, another factor is that of the last 20 million jobs that were created during the 1970's, only 11 percent of those were in any kind of goods manufacturing; 90 percent were in information and knowledge processing.

The other factor that I want to emphasize is that high technology industries develop in natural clusters. The two from speakers used the words research park, and here research park defines a geographic entity that would exclude industries such as Wiley or Intergraph. I think it might be useful to not only think of research park as a physical entity, but to think about a geographic region where there can be the necessary kind of interactions that occurs in proximity to each other. Because what is happening Nationally is that the factors which drive industry are the human resources, and those human resources are clustering in certain preferred geographic regions. Fortunately, Huntsville is one of those.

There was an article that was printed in Venture magazine entitled "Hi-Tech Highways', and that article identified Huntsville, supported by UAH, as one of the important emerging centers in the Nation. They mentioned others, such as Silicon Beach in Florida, supported by the University of Miami; Atlanta, supported by Georgia Tech; Houston supported by the University of Houston; Knoxville-Oak Ridge as an emerging area, supported by the University of Tennessee. This Venture article identified Huntsville as the region in Alabama best suited for high technology development.

But that conclusion was also reached in a congressional study, so there is lots of reason to believe that the State should invest its resources in the national competition in Huntsville as a high technology center.

Now, I would like to talk about some ways that UAH has interacted in order to facilitate the development of this high technology center here. One relates to the service sector. Now, normally we think in terms of the high technology sector. But the first illustration I want to use is what I would call the service sector. By that, I mean those people who are represented as multipliers in the economic statistics. Because when you have primary manufacturing, high technology contractors present, you cause service jobs also to be created.

Last year, UAH published a study called "The Impact of Commercial High Technology Firms on the Madison County and Alabama Economy." A copy of a summary of that is attached. That projection was made, if you recall, at the time the whole State, and the Nation, indeed, was facing what might be regarded as economic doldrums. And people were quite surprised that there were projections that the number of high tech employees in this community would rise from 25,000 to 35,000 over the next 4 years. That was a projection that the companies themselves were making.

And then, if you apply the service sector, jobs that result from the primary industry jobs, the number would go from 37,000 employees to 70,000. The payroll would go from $650 million to perhaps some $2 billion.

That caused a lot of people to wonder if this was really going to happen, but it also stimulated further investigations, and I believe that report was exceedingly helpful to other industries. The construction industry, for example now had a signal that to go ahead and start building. There was a validation of a need. This also served to alert the merchants and other kinds of service industries. Now, I believe the most recent data that we have, things like the collection of sales taxes or the article that appeared in the Huntsville Times indicating that the construction industry had expanded remarkably in this year over last year validated that the study did indeed anticipate economic growth. Therefore, that kind of study for the service sector was a very helpful one.

Now, the second example of cooperation is a proposal that we have submitted to TVA, and I do not want to go into a lot of detail about that; but I would like to indicate that we have proposed the creation of a center in Huntsville that would facilitate technology transfer.

It goes on the supposition that there will be no nonhigh technology industry in the future; that existing industries will innovate and will become stronger technologically; so that whether you are dealing with traditional industry or whether you are dealing with so-called high technology industry, it is all going to be very technically oriented in the future.

And basically what this—what this proposal is suggesting is funding from TVA along with other sources to help create a center that would facilitate technology transfer, particularly as it relates to automatic operations, robotics, advanced manufacturing, industrial automation kinds of activities. We believe this is particularly sound in this community because it does merge the electronics industry, which will be keyed to providing the control devices for automatic manufacturing, and the traditional industries together.

Now, I would like to indicate a third area of interaction, which is a little different, and that is the creation of the High Technology Resources Foundation. This is a movement by local leaders to suggest that the economic development of this region and the well being is intimately related to the post-secondary education institutions: That organization was created to address the needs of all of the universities.

Let me conclude by emphasizing what I call the proximity issues, that people in the past have thought that you could go away and get an education, or you can relate to a university at some distance. But increasingly, data is showing that the proximity issue, namely being close together, is crucial to this kind of economic development.

There is also a need for nationally oriented universities, and there will also be interactions between Huntsville and Silicon Valley and Huntsville and Boston. But you must also in the modern world have a direct local interaction where the region's universities are cooperating with the region's industries and the region's Government labs in helping each other. We have advisory committees for all of our schools at UAH which provide a direct and ongoing process for leaders from the Government labs and industries to help advise us.

Also, through the High Technology Resources Foundation, we have generated a 5-year plan as to how we must react to facilitate the development of this region, and that plan will be screened by the appropriate Government-industry representation in order to get the proper kind of validation in order to show that we do, indeed, have a plan that relates to the economic development of the region.

Finally, Senator Heflin, I would like to express appreciation to the committee for the opportunity to testify. S. 1286 does provide a useful process for the Government to facilitate economic development. In particular, the bill could be especially helpful for stimulating growth in a research park.

The Nation does have a number of research parks with great potential for economic development. Efforts that directly focus upon a geographic region and encourage interaction in that region are badly needed by the Government. And I am not aware of any other legislation that is directed toward that kind of target.

Thank you.

Senator HEFLIN. Thank you. Dr. Wright, give us a little bit of a background of UAH. And I apologize to Dr. Morrison, but Dr. Wright did tell us he had to get away, and so I will ask him some questions and then we will give you adequate time to talk, too, and to respond to questions, Dr. Morrison.

Dr. WRIGHT. UAH was created because of two forces that emerged in this community, and they directly addressed the kinds of activities that General Bunyard referred to. One was the need for an onsite undergraduate education, and that was an operation of the Extension Center from the University of Alabama in Tuscaloosa, offering basically freshman and undergraduate courses.

The second was a need for graduate education and research, which was directly stimulated by the Federal Government, and they at that time approached the University of Alabama and the legislature and said, in order for the Government research activity to proceed in Huntsville there needs to be a place where the people that we hire nationally can continue their education and interact with people at the university campus doing research.

And so those two forces then caused the university to emerge some 30 years ago when the courses first began to be taught and then some 20 years ago when the Research Institute was funded.

Senator HEFLIN. You have been fortunate in acquiring a number of outstanding scientists as your faculty, particularly those that have retired from NASA and other places. Would you give us what attributes they have added to your university?

Dr. WRIGHT. Yes, sir. Today, like I said, human resources are the crucial factor in any—in any technological innovation. And scientists wish to be in the presence of other scientists. They wish to be where there is a mass of colleagues where they can have stimulative interactions.

We have been very fortunate in the people we would hire from out of Huntsville. They would come here to UAH because of the proximity of the industry and Government operations. We have also been fortunate in that there is an exceptionally large number of talented people that are not employed by the university, but who are willing to cooperate with the university in various ways: Teaching courses, directing research, working in a cooperative vein with the faculty, working with the students.

So that there is just a continuous interplay between the technical community that is employed by the university and the technical community that is not.

Senator **Heflin**. Dr. Wright, I have had some private conversations with you about the future, particularly in two areas that do hold some element of promise nationally, internationally, and hopefully for this area, one being in the field of optics, primarily laser. Do you see a role that universities/industry could play relative to the development of laser technology with the existing facilities that we have here with Redstone Arsenal as the primary responsibility of the laser development for the Army?

The BMD, of course, has primary responsibility for ballistic missiles to date. There are certain things that are already here, other developments going along. I wonder if you might spend a little time giving us your ideas of how the cooperation of Government and university and industry might best serve the Nation as a whole in the field of optics and lasers.

Dr. **Wright**. Right; yes, sir. I think that is an excellent example. Let me start with factors that you may not be aware of. One, there is a professional society here of people who work in the field of optics. That professional society is the third largest optical society in the Nation in terms of local membership. Rochester, N.Y., and Tucson, Ariz., which are well-known optics centers, have larger memberships, but Huntsville has the third largest membership in the Nation.

Second, there is a Battelle study related to the economic development of a research park. It projects the types of industries which Huntsville might recruit in the future, and optics was indicated as one of those.

UAH was fortunate in receiving a guarantee from the UAH Foundation of $100,000 a year for the next 5 years to support a distinguished professor in the field of optics. We felt that optics was a valid area for us to become more active in research.

We constituted a task force then composed of representatives of the optics industry in town, some seven people, of the various Government laboratories, the Marshall Space Flight Center, the Ballistic Defense Missile Command, the Missile Command, the Missile Intelligence Agency, and then representatives of the university. That task force has begun its work.

It is charged to define what really is going on in the field of optics, optical systems, lasers, optical fibers in the area of Huntsville. Where is the research headed in the future? What will be happening here during the next several years? How can Huntsville position itself in order to be most effective in the competition with other regions? And then, finally, how should the university position itself? Who should we go after as a distinguished professor? What other types of faculty members should be added to UAH in the field of optics?

That group as a matter of fact is meeting today. Dr. Anderson, the vice president for academic affairs, is chairing that group, and they are proceeding to work that problem. So that is a very good example of the way that a university and industry and Government can cooperate.

The second area that I suspect you are referring to here is materials processing or materials science. Materials science is such a broad field that we at the university have identified the most beneficial area for effective interaction as materials processing. The Marshall Space Flight Center and NASA are moving toward the commercialization of space.

One obvious example would be the communications industry, which already has been commercialized in space operations. Another example relates to the monitoring that goes on from orbit. We believe that materials processing, taking advantage of those things that can happen at zero gravity, will be an exceedingly important part of the future.

The Marshall Space Flight Center has traditionally been strong in that area and we would envision that some sort of task force would emerge in this community to see how we could capitalize upon materials processing. There are bound to be industries that will grow from that research field in the future.

Senator Heflin: Well, thank you, sir. We appreciate it.

Dr. WRIGHT. Thank you. If I may be excused, Dr. Anderson will be here to answer any further questions.

[The statement follows:]

STATEMENT OF DR. JOHN C. WRIGHT, PRESIDENT, UNIVERSITY OF ALABAMA AT HUNTSVILLE

My name is John Wright and I am President of the University of Alabama in Huntsville. I am pleased to have the opportunity to testify before the Science, Technology, and Space Subcommittee of the Senate Committee on Commerce, Science and Transportation.

America's economic vitality, innovation and industrial competitiveness have become major topics of discussion among the nation's leading public and private institutions. Recognition is growing that all sectors of our society have a vital stake in economic renewal and important roles to play in bringing about that revival.

In the Spring of 1982, the President of the United States issued an invitation to the Business-Higher Education Forum to explore ways in which our national competitive position could be further strengthened through increased innovation and productivity. The Forum is an organization of leading corporate and academic chief executives which was formed in 1978 in affiliation with the American Council on Education for the exchange of ideas.

After a year long research and study effort, the Forum made one central recommendation. They said, "Our society must develop a consensus that industrial competitiveness on a global scale is crucial to our social and economic well-being."

The Forum's report, "America's Competitive Challenge: The Need for a National Response," finds that we must recognize the emergence of a global marketplace. It says, "Our mandate must not be to punish or retard the competitive gains made by other nations, but to do a better job of competing ourselves."

The essential ingredient in the process of technological innovation and economic competitiveness is the worker. While a growing number of people have outdated job skills, shortages of trained workers are developing in companies connected with technological advances—particularly technical personnel, engineers and scientists. A special report of the Business-Higher Education Forum estimates that "about 100,000 new engineers will be needed each year for the foreseeable future. Today, the United States is producing only about 60,000 new engineers per year."

According to James Naisbitt, author of "Megatrends" the United States has shifted from a mass industrial society to an information society, and the final impact will be more profound than the 19th Century shift from an agricultural to an industrial society. During the 1970s, we created almost 20 million new jobs in this country. We had never created so many new jobs before. Only five percent of those 20 million new jobs were in manufacturing, and only 11 percent were in any kind of goods-producing occupations. Almost 90 percent were in the information-knowledge-service sector. Furthermore, 80 percent of those new jobs were created by companies four years old or younger. Since 1967, Naisbitt continues, total employment in large corporations has declined every single year.

In a cover-story on "High-Tech Highways" in the September issue of Venture magazine, the author makes note of those factors which stimulate the growth of high technology industry: High tech industries develop most naturally in clusters in regions which have a strong technical university, government research labs and mature high tech companies. Since much of the high tech growth is from new companies, available venture capital is important. Other considerations are the amount of support given to a region by the state, tax advantages, a good transportation system, and the quality of life in a community. A university and other research and development facilities are other ingredients for development. And last, but not least, technical, managerial and assembly labor and the opportunity for additional training are essential.

The same article identifies Huntsville (supported by UAH) as one of the important, emerging centers in the country along with the Golden Triangle in San Diego (supported by University of California—San Diego), Silicon Beach in Florida (supported by the University of Miami), Atlanta (supported by Georgia Tech), Princeton, New Jersey (supported by Princeton University), Philadelphia (supported by University of Pennsylvania—Wharton), and three Texas locations—Austin, Dallas-Fort Worth, and Houston (supported, respectively, by University of Texas-Austin, University of Texas-Dallas, and Texas A&M and Rice Universities). Other regions of the south are mentioned as being in an earlier stage of development: Robot Alley in Florida; Columbia, South Carolina; and Knoxville-Oak Ridge, Tennessee.

Huntsville is recognized in the Venture article as the region in Alabama best suited for high tech development. This conclusion also was reached in a Congressional study of state government initiatives for high technology industrial development entitled "Technology, Innovation, and Regional Economic Development." It states, "Alabama has a considerable base to build on in the Huntsville area, which boasts some 200 high technology manufacturing firms and several advanced research programs at the University of Alabama in Huntsville."

Last winter a study entitled, "The Impact of Commercial High Technology Firms on the Madison County and Alabama Economy" was made by the UAH Center for High Technology and Economic Research. That report was prepared in the middle of the state's economic doldrums and projected remarkable economic growth in Huntsville. A summary of that report is attached as Appendix A.[1]

Two types of data now show that the anticipated growth is becoming a reality. The first piece of hard data is the city's sales tax revenues. These have been collected at rates of more than 10 percent for comparable months last year. An even more dramatic picture is reflected in construction. Recently the Huntsville Times reported that Madison, Limestone, and Marshall counties had construction activity for the first nine months of 1983 at 291 million dollars as compared to a level of 98 million for 1982. The September figures were even more dramatic. They were $63.4 million compared to $13.5 million for last September. The total include both residential and non-residential. They indicate a substantial increase in the economic base here. Ultimately this larger tax base will be reflected in increases in the State Education Trust Fund.

The report from the UAH Center for High Technology and Economic Research provides one example of cooperation between industry, government, and a university. The report was beneficial to both the public and private sector in making plans regarding the future of this region of the Tennessee Valley.

Another example of cooperation is a proposed UAH/TVA research and development center. This center will direct its research efforts toward advanced manufacturing techniques and processes which are required for adopting these new techniques to industries in this region. This project is summarized in Appendix B and is focused directly on stimulating technological innovation and economic growth. It is an example of the kind of project that can be carried out with adequate support to the University. I believe it also is the kind of project that is envisioned under Senate Bill S. 1286.

Stimulation of economic growth and meeting the international challenge for American's industry is everybody's business. Success will depend upon cooperation involving industry, universities, and government of all levels. The recent establishment of the High Technology Resources Foundation indicates the commitment in this part of the Tennessee Valley. We believe this region can serve as a healthy model for other medium sized high technology concentrations. Two editorials describing this local effort are included as Appendix C. We also believe the Federal government has a role to play in this development and therefore, support Senate Bill S. 1286.

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[1] Appendixes A, B, and C have been retained in committee files.

I would like to express appreciation to the Science, Technology, and Space Subcommittee of the Senate Committee on Commerce, Science, and Transportation for meeting in Huntsville and providing us the opportunity to give testimony to the committee. The Senate Bill S. 1286 provides a useful process for the government to facilitate economic development. In particular, the bill could be especially helpful for stimulation growth in a research park. The nation has a number of research parks with great potential for economic development. Efforts to enhance the development of these existing research park areas would pay dividends for the nation as a whole. The committee is to be commended for this bill.

Senator **Heflin**. Dr. Morrison, you warned him that he was leaving before he heard your testimony, did you not?

Dr. **Morrison**. No; I told him that he did not want to hear what I had to say.

Senator **Heflin**. No; he might, knowing you and the sly educator and the sly old fox like you, he might pick up a point or two. We are delighted to have you, Dr. Morrison. Dr. Morrison is the president of Alabama A&M, and has a rather renown institution here. Probably more international education in the field of agriculture and mechanics going on at your institution here than any other in the United States, and a great deal of activity is taking place at Normal, Ala., which is the location for—I reckon it is in the city limits of Huntsville now. It used to be Normal, Ala. But anyway, we are delighted to have Dr. Morrison.

STATEMENT OF DR. RICHARD MORRISON, PRESIDENT, ALABAMA A&M UNIVERSITY

Dr. **Morrison**. Thank you for those generous words, Senator.

I prepared my statement some days ago and, like all other papers, I suppose after you have some second thoughts, you would like to make some changes. However, I will read this.

Usually when I testify people are present who do not know very much about me. So I will start out by saying, my name is Richard David Morrison and I am president of Alabama A&M University, Huntsville, Ala. Also, I am chairman of the Council of 1890 Land Grant College Presidents, and a member of the executive committee of the National Association of State Universities and Land Grant Colleges.

My education and experience have been mostly in the land grant system. Academic degrees were earned at Tuskegee Institute, Cornell University, and Michigan State University. My professional interest has caused me to travel to many countries, including several Third World countries, and to Vienna, Austria, for the U.N. Conference on Science and Technology for Development.

My tenure of service in the land grant system has been continuous since 1937. That is when I came to Huntsville. Therefore, I have seen the immediate community develop through the years from a predominantly agricultural economy to one that is fastly approaching that of a high technology complex.

After having related this brief background information, let me plunge into the real reason I am here. There are two issues that will be considered in my testimony. The first one, "The Role of Research Parks in Stimulating Technological Innovation and Economic Growth," is of a high interest in this area, particularly because the setting and the interests are right for the development of the research park concept.

The second issue in my testimony will deal with S. 1286, a bill to fund research in advanced manufacturing techniques.

Returning to the first issue, the role of research parks should be that of fulfilling a felt need for research and development in a setting where all necessary components are available or have the possibility of being made available within the limitations of sound judgment. This thinking calls for carefully worked out plans considering the quality of human and natural resources.

The major role of research parks is to provide a setting that will make it possible for resources to be utilized in meeting needs, whether they are for innovative purposes or for growth and development. This role must include bringing together talent of high quality that is dedicated to a mission of keeping America viable and in the forefront when it comes to innovative ideas and economic growth.

Moreover, research parks may play an important role as a spawning ground for innovative ideas. They also may serve in an apprenticeship role for young scientists who need to develop further in sitting under more experienced minds. I am convinced that the research park concept provides a type of institution that makes it possible for inquiring minds and innovative techniques to be put to the ultimate test.

It comes clear to me that another role of research parks is to form a close working relationship with the educational system in their immediate environment; and, as needed, this relationship should be extended especially to appropriate universities.

Turning now to the second issue, S. 1286, a bill to fund research in advance manufacturing techniques and considering the state of the art, it seems most appropriate that attention be given to the development of a strategy for correcting our problems in the manufacturing arena. This bill points to a possible solution to a national problem that is affecting the economy of our country. This problem in a large measure has been brought about because we became lax in research and development as they relate to competition for manufactured goods on a world market.

There was a time when we felt strongly about the use of cheap labor in other countries for the production of manufactured goods in competition with our goods which were produced at a high rate of cost for labor. Presently we are confronted not so much with the cheap labor cost, but with the reduced manufacturing cost brought about through the use of technology. In addition, the superior quality of the manufactured products has significantly influenced the purchasing preference of the American people.

This bill, S. 1286, will help to put into place the components needed for an adequate solution to the problem of producing high quality manufactured goods that are competitive on a world market. The bill does give thought to the importance of human resource development—in my estimation, maybe not enough.

I recommend the use of existing research universities and centers for conducting research in advanced manufacturing techniques. These existing agencies no doubt will need financial support for the purpose of securing modern research facilities and highly qualified personnel. Moreover, the life line of research and development depend upon the availability and the quality of research institutions located in its immediate area.

My mind is focused upon the efforts presently under way in the Huntsville area. There has been organized a High Technology Resources Foundation that has as its major purpose to provide financial assistance to five local institutions for the purpose of helping to upgrade their high technology programs. The foundation is committed to raise $24 million over a 5-year period for distribution toward its high technology program efforts. I am sure this foundation could use wisely funds on a matching basis from other sources.

Alabama A&M University is one of the five institutions in the Huntsville area with great possibilities for making significant research contributions in a high technology program. For example, the university offers academic disciplines in both the science and technical areas.

However, the most promising and currently sought after areas include: one, computer engineering, electronic engineering, application to solid state electronics; two, materials science; three, applied optics, lasers, laser applications; and four, genetic engineering, bio high technology.

Academic offerings in some of the selected areas from the above list are handled through departments such as applied physics, biology, computer and information sciences, plant genetics, and food engineering, which offer graduate degree programs in their respective areas at this university.

However, at Alabama A&M University the entire high technology related research activities are being coordinated through an evolving unit identified as "Biology and High Technology Center."

The age-old question inevitably must be dealt with: What will happen to displaced workers when technology takes over? This bill addresses this question by providing for a retraining opportunity. A more serious question might be posed: In a country with over 230 million people, where technology will offer employment for a small percentage of the people, what will the others retrain for that will provide an average standards of living? This is the other side of the problem that should claim our attention, lest we solve one problem and create another larger one.

Finally, let me state that I support the basic tenets of S. 1286 and congratulate the committee for taking the leadership in presenting to the Congress a bill that has as its purpose to establish a program to conduct research and development for improved manufacturing technologies, and for other purposes.

I would say that in my thinking, Senator, that we must not forget that there are other elements of the educational process that we must give attention to, lest we might fail in our training for high technology. And the paper which I am submitting to you, that was presented on May 17 at a meeting I attended in Washington, was written by a person whom I think is very astute in areas of high technology, Ray Stata, of United Services, Inc.[1] He has also been associated with MIT for a portion of time.

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[1] Retained in committee files.

And I think in this paper he points out the concepts that I suggest, have spoken to, and that is we must be careful because engineers need to know something about English, other services that would make them good citizens and know how to cast their vote intelligently.

And these are some of the things that I think we should not forget. Now, before the question is asked, Senator, what are we doing in high technology in the areas that Dr. Wright spoke to that he thought were so fundamental? And I would encourage that we confine our interests in some of these areas and really work for the benefit of the whole community.

In the area of optics, we have at least seven Ph.D. professors working in that area already. We were very fortunate some years ago when we first started up through this program at the university to get a young fellow out of Washington who was very interested in developing physics at the university. And in cooperation with the Army and NASA, we were able to get going especially in one of his pet projects, which was crystal growth.

Unfortunately, that young man was lost to us in an automobile accident, but he had an understudy who has taken up, and his name is Dr. George. And he is the man who is responsible for pioneering in optics and in the laser work that we are in.

And we have in physics, we have one of the four master's programs in physics in the United States in that institution. And our program has—we have about 11 Ph.D. people. Now, we could not afford these out of the State money. So Dr. George has written proposals and so forth.

I just notice here on one thing, he has 18 graduate students, optics, laser, materials science; 7 Ph.D.'s in this program, $1,365,000 presently that he has raised outside of other funds that would come from the State college program.

And this is the kind of work we are engaged in, robotics, electronics, and this kind of thing. I just notice that he has a grant here of $97,000 in that area. And then another grant in optic laser work, $265,000 from the Navy; and material science of $1,100,000 from NASA.

Now, this comes about—I spoke about crystal growth. In competition worldwide, we won the right to send in space research, and that piece of research is a crystal growth in zero gravity. And why that is so important, the scientists tell me, is that it has the possibility of revolutionizing the chip that is so important now in our computer industry.

Now, I think that speaks for our university and our efforts to make a contribution in high technology in this immediate area.

Senator Heflin: Well, thank you, Dr. Morrison. It is rather remarkable testimony, and we are delighted to know of the efforts that your university is making to support the Government and to support industry in this area.

I know that you had a relationship with TVA for a good while, and that you are doing various things to date relative to some pilot programs. Would you tell us something about some of the high technology demonstration projects and other matters that you have been working on with TVA and some of the other agencies, and I believe, also in some curriculum development, too?

Dr. MORRISON. Yes; as I said, I came to this area when TVA was opening up in the area, when they opened up the dam. We have always worked in one way or the other with TVA, and tried very hard, and we have gotten some good cooperation even 30 years ago, and when they were deeply involved in research in the fertilizer industry. My training originally was in agriculture, and we went to TVA for early research in the use of fertilizer with the various crops, corn and so forth. And we have continued down to the present time.

I think our most recent efforts with TVA is to get them involved in our high technology biology efforts. And they have the research in biomass. And they supported us strongly in our work, and we are working along with them very well. And at the level of—still at the agricultural level, we have some work that is going on that will—that is not so much in high technology area, but it is supportive of an element of our society out there who is not so well off, and that deals with agricultural extension work that they support us on. And we have worked along with TVA, and this has been very supportive of our efforts.

Senator HEFLIN. Well, thank you, sir. We appreciate your testimony.

We are going to take a 5-minute recess. And when we come back, we will start with Mr. Peter Wood, the senior vice president of Booz, Allen & Hamilton.

[Recess.]

Senator HEFLIN. All right. This hearing will come back to order.

We are pleased to have Mr. Peter Wright Wood, senior vice president of Booz, Allen & Hamilton, which is a consulting concern, and Booz-Allen, a leading professional service firm, consulting in management and technology to government and industry worldwide.

He recently testified in Washington on the space station. He created quite an interest relative to future activities of industry in space commercialization and the use of the space station. We felt that his testimony relative to university, Government and industry cooperation on research and technology development would be very helpful, and we have asked him to give us testimony on this. We hope he can spend some time on the issue of space commercialization, since the Marshall Space Flight Center here in Huntsville has the primary responsibility on the space program for the material processing.

It has caused a very timely issue today with all of the experiments being conducted in the Spacelab, and you hear a great deal about it. So we are delighted to have you, Mr. Wood, and we appreciate your testimony.

STATEMENT OF PETER W. WOOD, SENIOR VICE PRESIDENT, BOOZ, ALLEN & HAMILTON INC.

Mr. WOOD. Thank you and good morning, Mr. Chairman. I appreciate your kind invitation, and it is an honor and a great pleasure to appear before you again, this time to discuss a very important issue of university, Government, and industry cooperation. I commend your decision to hold these hearings in Huntsville, among other places, because this is an area where cooperation among these three sectors is a recognized fact of life.

I appreciate your mention of our work, because we are very excited about this matter of processing organic and inorganic materials in a microgravity environment. And several others today have mentioned how important this can be to technology and the economy and the health field of this Nation, not to mention our technological leadership, which I think is one of the issues you have in mind.

Much of the work of the firm I represent, Booz, Allen & Hamilton, focuses on the relationship between Government and industry. We operate quite often at that interface, and we recognize how vital the health of that relationship is to the economic and technological leadership to the United States. But we see that we are not making the best use of that relationship, and we are not making the best use of a very fine intellectual input that can come if academia is a part of that partnership.

Mr. Chairman, industry in the United States has suffered in our competition since World War II with other industrialized countries which are growing very rapidly, often with our help, sometimes intentional and sometimes not intentional. And I think it is very important that we recognize we have lost our dominance in the automobile industry and in the electronic and semiconductors, and now we are beginning to see threats in the areas of computers, where the Government of Japan through its Ministry of Trade and International Industry is underwriting a great deal of the cost and effort for Japan to develop a fifth generation of computer.

And now we are beginning to hear that with the help of the Japanese Government the transport industry, the aircraft transport industry in Japan, is beginning to look like a threat to our industry in this country. So I think in the sense of where we stand industrially we have to find the means to take over that leadership again and step out briskly. And that means we have to take the best possible advantage we can of this combination that you have directed our attention to today.

I also think it very important to recognize that the health of industry and of our industrial base in this country is essential to our national security. And this was underscored a few years ago in the House of Representatives by the Ichord report, which found that there has been a serious decline in the Nation's defense industrial capability that places our national security in jeopardy.

So it is clear that there is a responsibility to be met by Government and industry, and in some ways that I will mention, but with the help of academia, to revitalize our industry and especially our industry that supports defense, which is so important here in Huntsville.

All right. The bill that you are exploring puts some emphasis on what can be done by this combination to support manufacturing technology and the strength of industry, and I do commend the purpose and goals of the bill. But I am going to suggest perhaps a little broader effort on a broader range. I am going to mention five categories where I think this is important, where some progress has already been made.

I think it is absolutely essential that we be innovative and creative. We have to make the best use of the technology that is available to us, and that requires a firm and broad partnership among these three sectors. All three of them are essential, because our universities are our source of the best thinking that moves forward. While industry provides the facilities in which to make things happen, the Government quite often is the catalyst and often the source of seed funding or grant funding that makes the whole engine go.

So I would like to talk about some of these possible forms in the time remaining to me and I would like also to give a few examples from, in some cases, other countries, in some cases things happening here, that we might look to and capitalize upon in order to try to make some progress.

The first topic is university and industry cooperation and research, and here I would like to mention what happens on in Japan. Sometimes we get a little tired of having Japan thrown up to us as an example of progress. We should remember that the thinking that enabled that, really came from the United States and the leadership and early help came from the United States.

So in a sense we could take some pride in the fact that it worked. But I think we can reverse the flow and take some lessons back, and in particular the fact that there was an almost mandatory participation by university professors, in consultation with industry on a regular basis, on committees oriented for specific industrial goals of the country. And it is really a part of the duties of professors there to meet, often three or four times a month, with industry, one-on-one or in committees, to try to move forward the objectives that the Government has set for industry in Japan.

It seems to me that that is something that could be a more important part of the landscape here, and perhaps the center of excellence that you have suggested might be one format in which that could take place.

In this country the Government has been a major source of R&D at universities. My understanding is that it is something like 55 percent of the total. But the industry participation is increasing. I think it is becoming more and more of a factor as industry moves into high technology and recognizes a need for the kind of thinking that can be found in our research universities.

So I think that it could very well be that if the center of excellence that you have suggested, and the bill would support, are established, that the research universities in this country would provide an excellent base for that.

Dr. Morrison, I think, mentioned the value of proximity, and I agree with him. And Dr. Wright also mentioned the importance of having research universities in this partnership, and this is a way to do it.

I am very pleased to learn of the progress here in Alabama in this cooperation, and I think it may be helpful for the university here to look to places where this has been a factor for a much longer period. It is a very prominent part of life around universities, and there are two places that I know of where this has been a very strong factor.

One is Stanford University, where there is a very close relationship with the electronic industry up and down Silicon Valley, and also a very close relationship between the university and the Ames Research Center of NASA, where there is a good deal of traffic back and forth in terms of exchanges, summer students coming into the NASA Center to work on advanced research projects; and further, Stanford is now operating a video instruction system for engineers in Silicon Valley.

MIT, through its Draper Labs and Lincoln Labs, has worked very closely, often on Government funding and with industry; and many of the local high-technology companies have as their nucleus, professors from the staff of MIT and in some cases Harvard.

I think these are two places where the synergism has developed remarkable results that have benefited the economy and technology in the United States as a whole. So it might well be that we can study the best lessons from these places to help make similar things—help them happen at other locations.

Abroad, especially in Europe, a lot has been done in this way; and in the United Kingdom there is a Royal Commission on Engineering that is recommending closer cooperation. And in France, it has long been a statutory right that industrial engineers have a sabbatical leave so that they can update their education and keep up with technology.

Now, the second subject I wanted to mention was Government and industry cooperation on research. And here I think we tend to think of both industry and Government as big institutions. But I think one factor that we have come to learn in our work at Booz-Allen is that more often than not making things happen depends upon a one-on-one relationship between what we call a zealot on the Government's side, who recognizes something of value and wants to turn it to the advance of the country, and a zealot on the industry's side, who keeps in close touch with him.

And one-on-one communication, I believe, is a very important factor. And I think, Senator, you yourself as an example of this will understand the value of individuals in making these things happen, because your leadership is clearly going to be a factor in bringing about the kind of cooperation we are discussing today. I think this is something where individuals selflessly see opportunities for the country or for a particular technology or area of science and they talk to each other.

There is a very interesting paper—in fact, a series of papers, by Professor Allen of the Sloan School at MIT, who did some diagrams based on interviews with large numbers of people in, for example, large research laboratories, such as the Bell Labs. They asked hundreds of people who they dealt with day to day and began to chart this.

He began to find that there were certain individuals who had large numbers of intersections. Then he asked people why so many of them talked to this individual, and the reason was that he always had ideas. These ideas could be turned into useful projects.

And then Professor Allen, in his research, went to that individual and said, why is it that you have all these ideas? Typically that individual would say, well, I guess it is because I keep in touch with a lot of people outside of this place, people where I used to work, people where I went to school, and we correspond and we meet regularly, and ideas flow back and forth, and I guess I try to put those ideas to work here in the lab.

Professor Allen, came to call these people "gatekeepers", because they were the gate through which useful ideas flowed into the institution. And I think this is an example of how an individual is important.

I think what we have to do is try to create environments with these centers of excellence that will make a nurturing place for these individuals to work and encourage and stay motivated, and have the opportunity to communicate freely with those sources outside the walls and even in other countries. Some of our leading professors here have found that they are even able to communicate by letter with professors heading research and materials processing in the Soviet Union, and we have been able to come out, I think, on the long end of those exchanges quite often.

There is a wealth of information in other countries, and unfortunately too few of us are bilingual in the United States. We would do well to study foreign languages more, and I think that is an element of our education that has gone neglected. Dr. Morrison talked about the importance of staying up with the liberal arts side of things and communicating in our own language. I think it is equally important that to tap technology and knowledge worldwide we should try as much as possible to have our—to pick up another language and get a working knowledge of it, so that they can translate and talk to counterparts in other countries on a broader scale.

This one-to-one thing has been an important element. It is something, if you are interested, Senator, that is vital to the work that Booz-Allen has been doing in trying to develop companies that are interested in using the space station, trying to help people understand the value of space, the meaning of microgravity, trying to think in a new way. We found that it does not pay to try to have mass meetings or mass mailings, but that you have to find the gatekeeper in a company that is research oriented, like a pharmaceutical firm, and then as much as possible make that individual and his forward-thinking associates aware of the power and potential of breaking free from the bonds of gravity, and try to project what will happen when you no longer have to deal with convection in the mixing of metals or where gravity will no longer interfere with the separation processes that are going to be very important to extracting pharmaceuticals or pure forms of compounds that are very important to advanced technology, to the manufacturer of gallium arsenide, for example, that would be an important element in high speed computers.

So again, we found out that it is very important to develop these one-on-one connections on behalf of Government with industry and to bring in the academic thinking that often is the key to unlocking these mysteries of science, to formulating the kinds of experiments that we can both try out on our space shuttle, where we have at least a few days with microgravity to work with, and to plan the kind of further experiments that would lead to productive processes on the space station, when we are able to deploy that.

And we now plan that that will be in the early 1990's if we can get an initial start fairly soon, and we hope that NASA will be successful in demonstrating the value of starting that.

I would like to point out that a lot of what we have been talking about in space does depend on developing processes for materials processing in microgravity. And some of the fundamental work in that field has begun right here at the Marshall Space Flight Center, and I am sure that Dr. Lucas can shed more light on that than I can.

But I think it should be known by everybody here and certainly to those who read these hearings that through NASA and through Marshall, it is possible for companies to enter into agreements to try out an idea in microgravity, in the drop-tube here at Marshall, where they get a few seconds of zero gravity, or in C-130 aircraft that can fly a parabolic pattern and can get you perhaps 20 to 30 seconds repeatedly through a flight, to try out your idea and see if it really does work.

These could lead to experiments on the orbiter, and they could in turn unlock the key to a high value or highly significant productive process that can make something of great value, like new medicines that might be the key to curing diabetes.

So I commend your interest in this subject, and that of the committee, and suggest that this is a good example of the kind of thing that can result from cooperation in these research parks and centers.

A third area that I would like to touch on briefly is the matter of things that can be done as an adjunct to large Government procurements, particularly improvements in industry.

One of the best examples of this sort of thing has been sponsored within the Defense Department, which is, as we know, one of the largest purchasers of products from industry. There is a program called Tech Mod, which means technology modernization. It started as an element of the F-16 fighter aircraft program within the Air Force.

And incidentally, that happened at a time when General Abrahamson was the head of that project; and as you know, he is now the head of our space flight program that is proving so successful in the operational beginnings of our space transportation system.

Now, General Abrahamson and his staff conceived an approach working with their industry supplier, which is General Dynamics. They were able to fund a very detailed examination of the plant where the aircraft was manufactured and do what they call a factory analysis on a very detailed analytical basis.

They looked at not only how things were physically made, but how the data systems are operated, how the QC system examines what is going on, how material is moved to be at the right place at the right time. And as a result of that study projects were identified which the company then funded. The company invested $100 million in capitalizing these ideas.

And out of that combination, the Government funding the start-up idea development and industry funding putting these things in place, came very dramatic cost savings on the aircraft. And those savings were shared, so that both the Government and industry benefited by the savings. And more importantly than that, the Government and industry and the United States benefited by a significant enhancement on that part of our industrial base.

Well, that same idea has been carried by the Air Force and later by the Navy and the Army to many other places. We do not have a way to project a viewgraph today, but I have attached to my statement several pages that are examples of where this tech mod approach, which is now called IMIP, industrial modernization incentives program, has affected dozens and dozens of industrial plants in the United States, and we project the savings so far to be about $4.5 billion.

But as I suggested a minute ago, that is not the important part. The important part is the Government and industry's cooperation with some innovative thinking has resulted in a major enhancement of our industrial base, which the Ichord committee found was suffering so badly.

I believe that there are ways to carry the same sorts of techniques through nondefense industry and to further pull ourselves up by the bootstraps to bring about a major enhancement in U.S. industry.

And I would like to point out that an important ingredient of that tech mod program was another Air Force sponsored program called ICAM, integrated computer aided manufacturing, which generated some of the very clever ideas that led to some of the automation and some of the integrated systems that are becoming so effective in these plants. And ICAM depends on some of the best thinking of our academic leaders in the fields involving manufacturing and control and use of microprocessing.

So here again is an opportunity with the three sectors together that produce something of great value to the United States, something that is part of the group by which we will regain that leadership that has been taken away from us a little bit.

The fourth matter I wanted to mention concerns the role of other Government policies in these partnerships, some dealing with the way the Government can move to protect intellectual properties of companies that might want to work with Government on joint efforts, such as proprietary information and proprietary processes. Some of the companies that we dealt with in exploring space commercialization have expressed a little concern about working with Government because they had ideas that they wanted to be their own and they worried about whether this huge Government that they were working with would protect their ideas.

I think consciousness of this concern is a first step as we look for ways to make this partnership work, and beginning to indoctrinate people in Government in the fact that the motivations of industry are profits, and that the protection of ideas is an appropriate thing for industry to do; and that the profit motive is part of what makes this industrial machine move in the United States, and that without a decent return on the risk and the capital that goes into these efforts industry cannot really move ahead.

So we are looking for ways to help people on the Government's side of the team recognize these facts, protect these intellectual properties, and acknowledge the risk and return issues that are always part of the game when industry works with Government, or when industry undertakes any innovation.

Another policy that relates to that is a whole range of tax and investment credit issues that need to be examined when we look at advanced technology, and when we ask industry to move ahead on something where it may take some years before the money at risk, capital invested, shows a return.

So, part of what we might do as we look at this three-way partnership is examine the tax and investment credit implications and implications of other Government policies on the equation, because those are all vital catalysts to making the chemistry of the thing work properly.

Finally, a few other remarks on industry, Government, and university consultations. Sometimes I am asked to participate on committees that deal across industry or across Government on some subject or other. And sometimes we find that we are all on one side of the fence, and we tend to be behind that fence and pointing across and blaming the other side.

But the committees and the joint efforts that work most successfully are the ones where all three sectors are represented. As an especially effective example of this sort of joint effort where communications have to be very open, there is something I learned last week. I met with Dr. David Low, who is at the Deputy Minister level of the Canadian Government, and in particular he is the director of Canada's Inter-Department Committee for Space.

Canada, as you know, Senator, does not have an agency like NASA, but it operates on this committee basis. And working very closely with this committee are just about all the departments of Government that have any technology connections, and something like 17 prominent Canadian universities and more like 50 companies in Canada.

Dr. Low is in very good communication with these universities and with these companies, as well as all the departments of Government, and this has resulted, on a very modest national budget for space, in some very interesting successes on the part of Canada's space program. The one that we perhaps know the best is the Canadarm, the arm that is mounted on our space shuttle, and it gets a little free publicity every time the television scans the orbiter. But I think it is a very good example of Canadian ingenuity and the cooperation of the various sectors that are coming together.

That arm is just one of many, many things that are going on where Canada is working across these three sectors, and in addition to some 600 other countries around the world, and moving ahead very thoughtfully despite the limits of their resources.

Mr. Chairman, these are some of the cooperative arrangements that I think are important to improving America's industrial base, and to benefit the economic and technological leadership in the United States in which you and I share a very serious input.

I think the key is synergistic partnership among these three parties. General Bunyard mentioned this word "synergism," and I think it is probably the most important benefit that comes out of bringing these three together, and that is that the net benefit that comes out of the whole thing is quite a bit greater than the sum of benefits that any one sector could produce on its own.

And when you bring the synergism to bear, I believe the benefits are limitless, and they certainly merit our thoughtful consideration as we face increasing competition from abroad. They do depend very much on motivated people in these various sectors having a chance to get together and to work together. I think we ought to provide the most fertile ground for them to work on, and to do our best to remove all the obstacles that we can for that cooperation.

I appreciate the chance to talk to you. I will be happy to answer questions.

Senator HEFLIN. Thank you, sir. We appreciate your very enlightening testimony.

I wonder if you might, since I know there is other testimony that you have given, you might give us some sort of listing, of interests by various industries in zero gravity, material processing or in some type of activity in space for commercialization. I am sure that you could not off the top of your head give us a complete list, but give us some interests that are ongoing in order that we might have a viewpoint.

Mr. WOOD. I brought part of the top of my head with me today, so I might do a little better. But we are preparing a list for your committee, Senator, that provides elements of what we are able to reveal. I mentioned proprietary interest a while ago, and many companies we are working with have asked us to play things close to our chest while they get their act together, get organized for what they might try to do so they can try to keep a little bit of leverage. But I think I can characterize some of these, and a few of them have been made public by one party or another, so I will try to mention them.

The best known example may not have come to the attention of everybody here, and something that Booz-Allen cannot take credit for, but it is an interesting example, is the partnership between NASA on the one hand and two companies in industry on the other: McDonnell Douglas Astronautics and the Ortho Division of Johnson & Johnson, which deals in pharmaceuticals, working together with a device which has been built by McDonnell Douglas which will perform electrophoresis in space.

And that is, it will cause a separation of closely related materials in a fluid by moving this fluid in microgravity in a flow, putting a voltage across it, so that it can be broken down into component streams. The original ideas for this came out of some work that was overseen by the Marshall Space Flight Center. And I understand that some of the early experiments in space on electrophoresis were conducted in another joint effort, which was the Apollo-Soyuz flights, involving our astronauts and our spacecraft and the Soviet cosmonauts several years ago where many interesting experiments were conducted. And that was one of them at that time, and it was determined then that electrophoresis, which can be carried out on Earth, appeared to be more effective in zero gravity.

McDonnell Douglas has now flown, I believe, five times in the space shuttles with their electrophoresis equipment on some test fluids, and I understand that they are now producing the first product in the current flight. And they found that in space the process can be something like 500 times as productive and produce a product which is five or six times as pure as what they can do on Earth. So this separation is important to many potential products, such as medications, as one example.

Another thing that can be done is the production of very strong alloys where metals which have different melting points, which would normally cause a gravity impact and prevent their alloying correctly into a homogeneous alloy, can be produced; and produce new high-tech materials, which could be very valuable to the manufacture of a more productive, more efficient spacecraft or aircraft and in some of the orbital construction that we look to when we talk about space stations.

The few other examples of things that we are looking into includes some work with the Chemical Manufacturers Association and some of their member companies on a project that would enable toxic waste monitoring from space, and we are very encouraged with those discussions.

In another case, we are working on a fermentation experiment with a pharmaceutical and biological company, and they are still at the point of formulating their experiment.

We have another form of separation process that we are working with, with a very small company that we met with yesterday, that has a separator that they believe can produce a very rapid separation in space. And we are now planning a zero gravity test of this equipment, first in aircraft with the support of the Marshall Space Flight Center and NASA, that would probably lead to something very productive in space.

In another instance, one of your firms here in Huntsville, the Wyle Laboratories people; are meeting with us and with several venture capital firms, where we think we can put together an enterprise that will outfit and operate a commercial laboratory in space that can then accept commercial business from other companies that perhaps cannot afford to mount their own space experiment, but would like to buy service from this laboratory to try out their proprietary ideas. And then, depending on the results, and the results can flow from a whole series of separate experiments where this laboratory is part of a space station, generate a number of ideas that they could put to productive work.

There are some very forward-thinking companies that are responding to these ideas that we are carrying to them on this one-on-one basis, and we think there is great potential for a wide range of business in space.

Senator HEFLIN. Do you foresee, as space commercialization develops, that on-ground base preparatory action can be profitable? By "profitable", I mean an exchange of ideas—interaction between university, industry, and Government?

Mr. WOOD. I certainly do, Senator. Ideas are very important to the beginnings of anything. And you cannot, if you will forgive us, legislate innovation. It has to spark from the right elements being brought together. It is almost like a chemical reaction. Bringing them together has to be done in an environment that is encouraging to free thinking, and where ideas that may sound silly at first can at least get a hearing, where people are not afraid to try a little bit, to brainstorm.

Brainstorming is a lot of fun, because if somebody throws out an idea and it really is not a good idea itself, but it triggers thinking in somebody else, then it has served a useful purpose, and somebody else's thinking may be what leads to the useful idea.

I think people of diverse backgrounds, once they get over some language barriers that sometimes are a problem, are the best combination for this kind of brainstorming, because something from each of several different backgrounds may be essential ingredients to what is happening. And sometimes the most important single ingredient in getting something new started is what we come to call a thought leader.

And a thought leader is somebody who does not let himself be fettered by things as they are or business as it is done today or life in a one G environment. It is very easy to let your thinking get bogged down because you know that everything gets pulled toward the center of the Earth, and it is very difficult to break free of that.

So I think these combinations where we bring together somebody who understands industrial processing of chemicals or petroleum related products or even explosives on the one hand, somebody who understands theories on another, and who may be focusing on pure research dealing with genetics or biological engineering, which is a new term that we are still getting used to, and somebody else who also understands the objectives of this country and things that have to be done, can get together and have a free exchange of ideas, then I think we are going to go somewhere.

If we do not have a vision that comes from this kind of chemistry, then we do not have something to shoot for. So this very early stage thinking is one of a whole life cycle of important results that come from these combinations.

Senator HEFLIN. Alabama has had some unusual strengths in certain fields for a number of years outside of our Huntsville area here, one being in metals with the aluminum industry, steel industry, various alloys, which we would put into the general term of metalurgy; and a second being in the area, particularly in Birmingham, of a large medical center that is highly recognized, that has—for example, it has one of the leading centers for diabetic control.

Now, the coalescing of these strengths with the potential, particularly relative to pharmaceuticals and metalurgy that have thus come out of space commercialization, could lead to the development here in this State of a center for innovative research, bringing together universities and industry, bringing together those strengths to develop for the future.

I suppose that having things that are located close together are an advantage. Would you agree with that?

Mr. WOOD. Sometimes I like to think of an analogy of the marriage broker, which is a role we sometimes play, and the young couple that you are bringing together who do not know each other very well right away, maybe they do not even talk in the same terms. And yet, you can begin to bring them together and you can begin to form a long-term relationship and, when the marriage broker backs away, let them build this relationship.

In this romance, we all know that propinquity is a very important element, and I think that is what you are drawing upon here. Somebody today has mentioned the importance of communication, and we are talking about not just being able to write letters back and forth, but the kind of close understanding across the fence between two sectors or between two organizations, the kind of understanding that comes from an extended dialog.

And that extended dialog is best nurtured when people can see each other weekly or almost on a daily basis. So I think the geography is an important factor, even when communications technology is moving as fast as it is, we can communicate around the world just by picking up a telephone and using our satellite systems.

There still is a kind of a trust and understanding and kind of an intuitive link between the parties that depends on their working together. I guess the ultimate would be when you combine all of these into a single individual. Some of the most interesting individuals I have met have been people who hold degrees in medicine and have perhaps gone through a school like MIT where they work with new devices and new materials, and then within this one intellect can conceive, say, an artificial heart, where you can conceive of something you could do if you just had new, lightweight, noncorrosive alloys of some kind.

Well, when we get that partnership working together very closely it is almost like several intellects within one brain working all these different dimensions of the problem. I think wonderous things could result by more of these close relationships that are interdisciplinary, and that proximity is a very important element.

And I think if medicine and metals, advanced metals, to name two that you mentioned, could work together, the potential for devices that can be used in advanced surgery we have begun to learn about could be moved along more rapidly. I think that is certainly worth the best thinking of some of the thought leaders in those fields, getting together and finding ways to do it. Call it medical engineering, perhaps.

Senator HEFLIN. One other interesting part of your testimony that ties in a little bit with the testimony of a witness yesterday in Birmingham is the necessity of continuing education and exchange of ideas, and perhaps some sort of more formalized gathering, the idea of maybe enlisting professors going to another institution, but even on a basis to get beyond what we generally concede today as a continuing education; in other words, getting together on weekends and have a few subjects, and they sometimes turn out to be drinking bouts and social events, but to have more of a center, perhaps in centers under this bill, by which there would be in effect camps or summer camps, maybe some sort of Aspen Institute.

They bring together people on different ideas, keep them together for a period of time and exchange ideas. The cultivation and the thinking of leaders has developed well there.

Perhaps in this bill there could be some type of a provision for some formalized areas of where there could be centers to gather people for more than just weekends, but for periods of time. People could gather on certain subjects and exchange ideas.

Do you foresee any type of a structure of this kind on more of a formal basis that legislation could address and could initially provide some seed money or some incentive to try to create the better exchange?

Mr. WOOD. I certainly think that the country would benefit if these sorts of arrangements are encouraged. And I had the opportunity to spend 2 weeks at the Aspen Institute in 1978, where there was a diverse range of people there. Probably most of the people in that particular course, which dealt with the writings of great philosophers, came from industry. But there were several who were not, and the ones who were not were underwritten by other means.

It is an expensive course if you go as a paying member, and finding a way for others to go who have something to gain and something to contribute that might not have the means to take such a course would be very helpful.

I am inclined to feel that there is a danger of overinstitutionalizing something like this and beginning to fetter it in some way, and rather than making it a Government sort of a meeting, I would really like to see something that provides a little help to the best of what is happening today, whether it be Aspen Institute or one of many other worthy forums, but that probably they should have a range of goals to qualify for this sort of help, where they are dealing with ideas that somehow support a national need or a national issue.

National issues that we have talked about today include security, industrial readiness, technological leadership, health, communications—our total leadership position in the world. And I think among these ranges of issues, and there are many that are important, it is possible to find challenging topics for such symposia, perhaps, that would merit Government support in most worthy cases.

Now, the other kind of thing that you made me think of is a little more ad hoc. Where there is a particular question to be dealt with, sometimes the bringing together of people from diverse backgrounds helps a lot.

One occasion that I can think of was a meeting that NASA sponsored a few years ago at Snowmass, which is not far from Aspen, again, where they brought people from the steel industry, from petroleum, from agriculture, and some space knowledgeable people, to try to get something going on the subject of what can space do for these various segments. And in the early stages, I understand there were problems of communication, people not speaking the common language.

But as that was overcome, ideas began to flow and benefits began to accrue to all of these people. That was not really continuing education in the usual sense, but it proved to be an education to all of the people there.

I am a very strong believer in continuing education, even if it is only a matter of each of us turning off the tube and picking up a book some part of the evening of every week. I think your distinguished guests from the universities will agree there is too little reading going on today and certainly too little continuing education.

And there is such an expanding universe of knowledge that we could take advantage of, if more and different kinds of people would somehow at least get in touch with that body of knowledge—anything that can be done to create forums where more of this is done and where it does not depend on the ability of a company or an individual to pay the price of admission would be a forward step, and I would certainly employ that activity.

Senator HEFLIN. Well, thank you.

Mr. WOOD. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF PETER WRIGHT WOOD, SENIOR VICE PRESIDENT, BOOZ, ALLEN & HAMILTON INC.

Mr. Chairman, members of the Subcommittee on Science, Technology, and Space, I am Peter Wood, Senior Vice President of Booz, Allen & Hamilton. It is an honor and a great pleasure to appear before you again, this time to discuss the important topic of university-government-industry cooperation. I commend your decision to hold these hearings in Huntsville, an area where cooperation among these three sectors is a recognized fact of life.

Booz, Allen is a leading professional services firm consulting in management and technology to government and industry worldwide. Our work includes extensive consulting in management and technology systems for many parts of the United States Government. I have been with Booz, Allen for sixteen years, principally in defense and space activities, including considerable work at government-industry interfaces.

Much of Booz, Allen's work focuses on the relationship between government and industry. The health of this realtionship is vital to ensure and enhance the economic and technical leadership of our nation. Yet often we see evidence that that relationship is not as healthy as it should be.

American industry has suffered in the international marketplace. American manufacturing productivity growth rates are among the lowest for industrialized nations. We have lost our dominant position in the world automobile industry and are just barely maintaining superiority in semiconductors and electronics. In both of these cases, the rising star has been the rising sun of Japanese industry, well served by the aggressive policies of its government, which orchestrated teamwork with industry and the universities. In the case of automobiles, the Japanese auto industry was so protected by import restrictions between 1952 and 1965 that a highly competitive and efficient domestic auto industry was able to evolve. Today, Japan's nine domestic car manufacturers are potent international competitors. In the case of semiconductors and electronics, Japanese industry benefitted from its government's policies of targeting knowledge-intensive "sunrise" industries for special assistance. In the most recent example, Japan's Ministry for International Trade and Industry is funding most of the $1 billion cooperative project with industry to develop a fifth-generation supercomputer. Further, experts have begun to view Japan's aircraft industry as a potential competitor to U.S. aerospace, again, with substantive direct Government support.

Beyond the importance of our industrial performance to our leadership in international trade, the health of America's industrial base is vital to our national security. The Ichord Report of 1980, prepared for the House Armed Services Committee, found a "serious decline in the nation's defense industrial capability that places our national security in jeopardy." It is clearly the responsibility of both government and industry to find ways to stop this decline.

Senate Bill 1286 suggests a number of cooperative programs to improve manufacturing technologies. The Bill provides for grants to support research in manufacturing technologies as well as for the establishment of Centers for Manufacturing Research and Technology Utilization. I commend the purpose and goals of this Bill, but I suggest that an even broader effort is needed to meet the great challenge we confront.

Promoting innovation and progress in industrial R&D need not involve an enormous government bankroll for industrial R&D grants. It must, however, involve a firm and broad partnership among industry, government, and our universities. All three partners are essential: universities are the source of America's greatest research potential, government must provide the incentives for basic research, and industry must ultimately translate that research into productive innovations. In the remainder of my testimony I will discuss some possible forms that partnership might take.

University-Industry Research Cooperation: It is important that researchers in industry and researchers at universities cooperate and interact regularly. In Japan professors typically participate in industry-university committees 3 to 4 times each month. This is considered a regular part of their duties, unlike the American practice where professors consult in order to augment their incomes. Our government might well establish such cooperative efforts in schools where it funds research.

American universities are becoming more responsive to industry needs, and the reverse is true as well. Industry grants now represent a much larger part of the operating budget of major research universities, and industry may soon replace the federal government as the chief source of university-based basic research funding (the Federal government now supports about 55 percent of university R&D). If Centers for Manufacturing Research and Technology Utilization are established, America's research-oriented universities are probably the best home for them.

In addition, research universities are beginning to assume a new role as centers for lifelong education of researchers in the private sector. Standford University operates a video-instruction system for on-site continuing education of Silicon Valley engineers, and MIT is considering a similar program for its industrial neighbors. Not only are programs like this important to ensure that industrial researchers continue to develop professionally, but industry contact also helps keep university researchers in touch with the specific needs, trends and developments in industry R&D. Programs for lifelong education have also received considerable attention in Europe. A Royal Commission on Engineering in Britain recently recommended a similar program for British universities, and in France, sabbatical leave for industrial engineers is a statutory right.

Government-Industry Research Cooperation: The Federal Government must ensure that industry researchers have access to government R&D activities. At MIT, Sloan School researcher Professor Thomas Allen has demonstrated that there exist in all research laboratories certain key researchers with a high level of contact outside their own lab and a high degree of consultation and respect with their coworkers. These researchers—or "gatekeepers" in Allen's terminology—are the chief sources of new ideas within these R&D labs. Government agencies should try to identify industrial gatekeepers and put them in touch with key researchers in Federal labs, where some of the nation's most exciting and fundamental work is going on.

A similar approach has been a key element of Booz, Allen's recent work for NASA in stimulating industrial users for a proposed Space Station. In conducting this effort we quickly learned the importance of identifying the gatekeepers in a firm's research department, and then, acting with the sanction of the firm's executives, exposing these key personnel to the progress being made in NASA research. We suggest the potential advantages such firms could enjoy by developing new industrial processes which take advantage of the attributes of space. In many cases, the lure of working with Huntsville's own NASA Marshall Space Flight Center and its materials processing team, and of exploring new processes in Marshall's microgravity facilities, and eventually on the Shuttle, have produced negotiations for cooperative agreements with NASA.

The precedent being set by NASA as it works to facilitate cooperative research with industry and academia should be watched by other research centers in the Federal Government. Only by involving industry in government research programs will the advances made in this research ever be incorporated into economically useful new technologies.

Procurement Based Industrial Improvements: The Federal Government, as a major purchaser of private sector products and services, has great opportunities to influence the health and policies of our industrial base. The Department of Defense, one of the largest single purchasers of industrial products, has recently responded to this opportunity with some exciting and successful new initiatives.

The Technology Modernization (or Tech Mod) Program has become a particularly promising means of generating productivity enhancement and strengthening our industrial base. This program was originally devised by the Air Force for the F-16 aircraft program as a means of providing incentives for cost-saving improvements in the manufacturing process. Under the Tech Mod program, the Air Force funded an extensive factory analysis which resulted in the definition of opportunities for capital improvements to General Dynamics' F-16 plant at Fort Worth. General Dynamics then funded the capital improvements, and both parties are sharing in the resulting substantial cost-savings. The program uses innovative new technology in such fields as composite layup, robotics, automated common data bases, and integrated computer aided manufacture (ICAM), another Air Force program which draws upon the best thinking of industry and academic researchers. The Tech Mod approach has been applied to other plants in Air Force programs, and the other services are following suit.

Tech Mod has now been adopted as a DOD-wide Industrial Modernization Incentives Program (IMIP). IMIP cooperative projects currently under way with dozens of contractors are projected to save billions of dollars in costs in many of our nation's most important new weapons systems, and each such project improves the productive capability of the U.S. Industrial base.

Other DOD initiatives are included in its Manufacturing Technology Program. That program plans to spend around $1.5 billion over the next 5 years to improve manufacturing technology in the industrial base. These efforts stress transferring the results of new technology projects to other ongoing programs and reducing risk for private sector investment in new technologies. These policies are based upon cooperation, and that cooperation—the building of a real government-industry partnership—is vital to sustaining our national defense capability. Similar teamwork might well serve a broader range of U.S. industries.

Government Policies: Government tax and patent policies are another important element in building a real government-industry-university partnership. Firms with which we have been dealing on behalf of NASA are especially concerned about the government's ability to protect proprietary information and guarantee intellectual property rights for ideas developed under cooperative agreements. The government must act to remove those doubts as quickly as possible.

Tax policies are important to stimulating investment in R&D. The recent streamlining of the depreciation allowance was a boom to capital improvements incorporating new technologies. Perhaps even bolder schemes are appropriate: for example, tax credits could offset R&D or capital costs associated with new technologies, such as those involved in space commercialization.

Industry-Government-University Consultation. I have been privileged in recent years to serve on committees including representatives from industry, government, and academia. These groupings invariably lead to a valuable exchange of viewpoints and real give and take among participants from the three sectors. The result is always preferable to having members of any single sector line up behind their own fences and point accusing fingers at the other sectors. Such communication is vital to building any real three-way partnership. I spoke last week with Dr. David Low, who heads Canada's multifaceted space program. He told me of the vitality of the Canadian partnership for space scientific and industrial progress, which involves more than a dozen Government departments and agencies, seventeen universities, and more than fifty companies.

Mr. Chairman, these are some of the cooperative arrangements I feel are important to improving America's industrial base. They complement those suggested in S. 1286. The potential benefits to the economic and technological leadership of this nation from such synergistic partnerships of government, industry and academia are limitless, and they merit your thoughtful consideration as we face increasing competition from abroad. I appreciate the opportunity to be here this morning and to share with you some of my thoughts on this critical issue.

SELECTED AIR FORCE, NAVY, AND ARMY PROGRAMS

Status and company	Systems	Project benefits (millions)
AIR FORCE		
Current programs:		
General Dynamics [1]	F–16	$372.
Westinghouse	F–16, E–3A, ALQ–131, B1–B, ASPJ	$430.
Rockwell (plus subs)	B–1B	$400.
Boeing military aircraft	KC–135, B–1B, B–52, OAS/CMI	$55.
Pratt & Whitney (plus, subs)	F–100, TF–33, TF30, PW 2037 Engines	$352.
General Electric (plus subs)	F–101, F–103, F–108, F–110, F–404, T700, TF34, TF39 Engines.	$155.
Hazeltine	Seek TALK, AN/APX–76 IFF	TBD.
Sonicraft	MEECN(616A), diversity reception equipment	TBD.
Hughes Tucson	AMRAAM	TBD.
Gelac/Avco	CS, B–1B	$18.
Under discussion:		
ABA	Turbine engine spares for F–100, F–101, etc	TBD.
FAFNIR	Precision ball and roller bearings for F–100, F–101, etc.	TBD.
Varian	Traveling wave tubes for ALO–119, ALO–165, etc	TBD.
Goodrich	Spares—wheels and brakes	TBD.
AAI	Spares—trainer components	TBD.
NAVY		
Current program:		
Grumman	Factory Mod for F–14, A–6, EA–6, C–2, E–2	$400.
Northrup	F/A–18A center/AFT Fuselage	$250.
Hughes (radar systems)	APG–65 (F–18), AWG–63 Radar Update (F–14) APG–63 Radar (F–15) (Air Force participation).	$61.

SELECTED AIR FORCE, NAVY, AND ARMY PROGRAMS—Continued

Status and company	Systems	Project benefits (millions)
Under Discussion:		
Thiokol	Factory Mod for EX-104 standard missile and harm missile.	$150 to $400.
IMCO	MK-12/EX-70 booster case for SM-2	$50 to $100.
ITT Gilfillan	SPS-48 radar	$18.
FMC	MK-45 mount, MK-13 missile launching system	TBD.
ARMY		
Current programs:		
Avco-Lycoming	M-1 tank engine, helicopter engines (CH-47D and AH-IS).	$280.
Harris Corp	MICNS, anti-jam moden, RTACS	$230.
Under discussion:		
Bell Helicopter	AHIP (OH-58D) helicopter	$105.
Hughes Helicopter	Apache (AH-64) helicopter	$124.
General Dynamics Land Systems	M-1 tank	TBD.
FMC	Fighting vehicle system (FVS)	TBD.

[1] General Dynamics F-16 subcontractors are listed under selected joint programs because of other service involvement.

Note: The projected benefits are preliminary, order-of-magnitude estimates which span a number of years and cover both contractor and Government savings. They are shown to indicate the significance of the program.

Source: OUSDRE June 1983.

SELECTED JOINT IMIP/TECHMOD/IPI PROGRAMS

Status and company	Systems	Participants	Project benefits (millions)
Current program:			
Hughes, Tucson	Phoenix, Wasp, Maverick, TOW	AFSC NAVMAT DARCOM	TBD.
Martin Marietta	Patriot, Pershing II, Mate, TCCF (CNCE), Pave Penny, TADS/PNVS, Copperhead, Lantirn, Navy 5, Atlis.	DARCOM NAVMAT AFSC	$520.
F-16 subcontractors: Westinghouse (LIMA), Simmonds Precision, Tracor, Sperry, Delco Sierrancin/Sylmar, Aerospace Avionics, Arkwin, Goodyear (AZ), Airsearch, Sundstrand.	F-16, B-1B, JTIDS, AMRAAM, LANTIRN, F-18, Poseidon, M-1, AV-8, Bravo, others.	AFSC AFLC NAVMAT DARCOM	$107.
Singer-Kearfott/Collins	Joint tactical information distribution system (JTIDS).	AFSC DARCOM	$120.
Under discussion:			
Hughes (all groups) IBM	Total factory Mods	NAVMAT DARCOM AFSC	TBD.

Source: OUSDRE June 1983.

Senator HEFLIN. Maybe we should have lunch, maybe we could go ahead. We have got some very interesting witnesses and I want to take some time with each of them. I do not want to rush with this thing. Mr. Charles Dean, are you in a big hurry? What is your timeframe?

Mr. DEAN. I am all right.

Senator HEFLIN. Mr. Fundingsland, what is your timeframe? Are you all right, sir?

Mr. FUNDINGSLAND. I am all right.

Senator HEFLIN. Do you have a plane to catch?

Mr. FUNDINGSLAND. By 4 o'clock, you are all right.

Senator **Heflin**. Well then, perhaps we had better adjourn for lunch and come back at 1:30. All of the witnesses and the people with them, there is a lunch at the Hilton.

AFTERNOON SESSION

Senator **Heflin**. The hearing will come to order, and we are delighted to have Mr. Charles Dean, Director of the Board of Directors of the Tennessee Valley Authority.

And I might say, TVA over a long period of time has been interested in cooperative interrelationships between educational institutions and industry, and as a Government agency has sort of brought things together in different localities. TVA extends in Tennessee, Alabama, Mississippi, Kentucky, primarily, and at the University of Tennessee in Knoxville TVA has had a long-time relationship with various institutions in Alabama and in Kentucky and in Mississippi.

We are pleased to observe what TVA did with moneys that were allocated under a jobs bill. We got a sizable portion of the jobs bill money from the Government agency and they designated a substantial portion of that toward future recruitment of the work force through the programs designed to upgrade craft skills, demonstration projects, and pilot programs relative to high technology. They used some of the money for educational institutions in this area. John C. Calhoun Community College in Decatur, which is primarily a technical trade school; and Alabama A&M.

And they worked on some pilot programs on curriculum reform as to the future of high school and elementary school education, a number of different things in this regard. And one of the purposes of the bill that we are having hearings on involves retraining, as well as all other aspects of the academia and industry and Government relationships.

Mr. Dean, we are delighted to hear from you at this time.

STATEMENT OF CHARLES DEAN, CHAIRMAN, TENNESSEE VALLEY AUTHORITY, ACCOMPANIED BY DR. BILL BOND, OFFICE OF NATURAL RESOURCES AND ECONOMIC DEVELOPMENT; AND BERNARD H. ZELLNER, DISTRICT ADMINISTRATOR

Mr. **Dean**. Thank you, Senator.

I have with me Dr. Bill Bond, who used to operate our OACD over at Muscle Shoals. He has been transferred to Knoxville, to the Office of Natural Resources and Economic Development; and Mr. Bernie Zellner, who works out of the north Alabama area as the district administrator. They are here to back me up if I run aground.

In accordance with the written instructions, I will not read my testimony. It is filed for the record. Instead, I have a few notes on a piece of paper that I will refer to and make a few general comments; then if you have any questions, that will be fine.

We are very happy to do anything that will improve the economic situation in the TVA area, the valley that we are obligated to serve. As you well know, recovery in this area has been slower than most of the Nation for a variety of reasons. One of them is cutbacks in certain heavy industries.

Some of these heavy industries may never fully recover to their prerecession levels unless they employ some of the most advanced manufacturing techniques, which might be developed under provision of S. 1286. In other words, the idea of improving manufacturing techniques is very interesting to us. A lot of companies came to this valley with heavy industries to take advantage of hydropower. TVA is in shape now where only one-sixth of our generation is hydropower, and the rest of it is just like other power sytems, coal and nuclear.

So, our power is no longer very inexpensive as compared to the rest of the United States. So we need new techniques for people to make the same products with less power, and this is the type of thing that you get by developing advanced manufacturing techniques.

The good news is, of course, that we are, in this valley, getting expansions and additions by industries that have taken advantage of the advanced manufacturing techniques.

For example, Weyerhaeuser over in Mississippi has built a very modern paper mill. It is almost zero discharge from the environmental standpoint and it is right up to the minute in various other ways. It uses wood waste, biomass, to generate electricity. We are proud to have plants like that move into our area, because even though they generate electricity, they hire a lot of people and use a lot of our electricity, too.

Nissan is another example of a very modern truck manufacturing plant up there near Nashville, Tenn., which uses robotics and computerized machine tools, and is a good example of the latest thing in industry, so we are picking up some really first class industrial processes while we run into some trouble in a few other places.

A. E. Staley Co., Loudon, Tenn., is another example of a company that processes corn into various things, such as feed and syrup, and sometimes alcohol.

The Eastman Corp. in Kingsport, Tenn., is another company that has taken advantage of the latest industrial techniques, which includes the manufacture of ammonia from coal, which is a process that TVA built a pilot plant for, over at Muscle Shoals.

We are seeing spinoff industries and expansions particularly in two areas of high tech development which have been mentioned before today: the Huntsville area and the Oak Ridge area. TVA is interested in both of these corridors and has assisted in their development. We have also worked with various schools in the valley, as the Senator pointed out, with research contracts, for one thing, and also worked with them in specialized education to upgrade the educational skills of people who have been displaced by changes in the industrial climate.

We are now interested in, and give some thought to, promotion and industrial development. None of these things take place overnight, but we think there is room for a third high tech area, really, on property that we own at Muscle Shoals. As many of you from north Alabama know, we have the National Fertilizer Development Center over there, and it is the home of the International Fertilizer Development Center. These two groups have scientists and engineers who develop most of the fertilizers that are used in the free world, along with other agronomic processes.

We can see the possibility of expansion. There is an organization in the Shoals area known as Shoals, Inc., which is devoted and dedicated to the proposal that we expand and build on the high tech that we have at Muscle Shoals in primarily the fertilizer and agricultural field, and really offer something to the world, and of course offer some things, such as more jobs to north Alabama.

We could promote spinoffs of that type, spinoffs related to agriculture, and complementary programs connected with our existing fertilizer programs. We might see some things such as a national biomass center located on our reservation at the Shoals.

Biomass is kind of a buzz word, but one of the projects that we are working on, for example, is the use of waste hardwoods for production of alcohol. We almost have that process ready for a pilot plant. That is the type of thing that TVA can do best. We see a bright future in the proper uses of our wood resources.

We might also see in the future a nitrogen center over there. We are at the point now where it is possible, or perhaps possible, to breed plants which will generate their own nitrogen. We have such plants now, specifically certain legumes. We can see the possibility of developing other plants for breeding, cross-breeding, and creating plants that would fix much of their own nitrogen out of the air.

The air is about 70 percent nitrogen, and if you create a plant that can generate a lot of its own nitrogen, you could cut the cost of fertilizers dramatically. So we have the nucleus of another high tech area over there. We can use the kind of help and research that parts of this proposed bill would offer.

So we envision the possibilities of an entirely different type of high tech that relates not to space or computers, but to agricultural process that would be suitable for the Muscle Shoals area. We have a piece of real estate over there to put it on, and we intend to keep plugging away at it. We have heard these things take time, but we get pretty impatient on long-range projects.

Senator, the rest of my material is covered pretty well in my written statement, if you would like to ask me some questions about things that are in my statement.

Senator **Heflin**. Well, I would like to go a little bit into the retraining concepts that you foresee. Those people that feel like technology is going to evolve itself into an ever-changing—some say that what may be the latest technology 10 or 15 years from now, that 5 years later, it will be obsolete. Then we may have to go through a retraining of our work force and skilled work force every 10 years, or some periodical timeframe.

I wonder how you can foresee Government helping and participating in this; and also, whether there is a role that universities can play with this?

Mr. **Dean**. We are, of course, a Federal corporation, so we are in the sense Government, in that respect.

In fact, we had two main parts of our operation, the power program which is financed by our electric consumers; but the rest of it, as you well know, is financed by appropriated funds. And as a Federal corporation, as you pointed out earlier, we have received some money from some so-called job bills programs, and it has enabled us to expand our training programs.

Now, as to the way we operate those training programs—you know, there was a time, when TVA first came to the valley, many years ago, when they sort of did everything on their own. But now we have learned, or TVA has learned, through experience that the best way to get things done is to work with existing institutions.

It is safe to say that every training program we have is in cooperation with some school, some technical college or some university; and that is why we have them scattered around in so many different places. We do different things in different places. It depends on what the needs are. There is a place in upper east Tennessee where we have furnished, with Federal funds, some computerized machine tools, and then the State tech people teach people how to use the computerized machines.

We have helped furnish robotics in the Chattanooga area. Some places we offer instruction in more traditional skills. I do not think that we are going to see the time when everybody is going to be operating a computer. Somebody is still going to have to be able to weld and repair machinery and things like that. So over at Yellow Creek in Mississippi, where we have had to defer a nuclear plant, we have some schools where we are teaching welding and the repair of diesel engines and practical things like that.

We are in a variety of programs. In almost every case, it is a case of cooperation with Government, and in some cases with private industry, particularly when a private industry comes into this area and they need certain skills to staff their plant. Quite often, along with the States involved, we are able to promise them, "Look, you get the plant in, and we will get you some people trained to work in the plant."

So we have been very pleased with this type of arrangement, and I do not know of anything TVA has been involved in that is more universally well-received than the training programs. The danger is in getting people's hopes up. I mean, when you are training people to work in a specific plant, that is one thing. They have got something specific waiting for them. The danger in general training (something that has to be watched) is to make sure you do not train a lot of people on jobs that do not exist, because you get people's hopes up. That is kind of tricky. You do not know whether the industries come in because the people are training and waiting to go to work, or the chicken and egg kind of thing. So you have to have some of both.

Senator HEFLIN. Well, many industries find that their needs are also evolving and changing, and I notice that one of the proposals in the job money was that TVA would customize industries' needs; that if an industry in the Tennessee Valley felt like that they needed to plan for a new type of work force, a work force that would require some different training or new training, then TVA would in effect lend one of your experts who could come in and could work with that industry and perhaps with a trade school or even the university, and try to customize a training program to meet the demands for that industry in the future.

I was interested in seeing if that was one of the programs that was available that TVA made with the jobs money.

Mr. **Dean**. I might ask for Billy Bond to comment on some of the more successful programs we have done for specific industries. Do you have any good examples?

Dr. **Bond**. No specific industries, but that is where it has been most successful. That is where an industry comes in and wants TVA to be its broker in training.

Mr. **Dean**. What do we have in the Shoals area now?

Dr. **Bond**. No industry specific type of training.

Mr. **Dean**. Upgrade crafts training. The generalized type.

Dr. **Bond**. Most everything there is craft upgrading.

Mr. **Dean**. Craft upgrading.

Senator **Heflin**. With TVA and its research program, I gather that you have been involved in the Muscle Shoals area and some of the universities have been working with you, maybe Auburn and some of the others. I wonder if maybe Dr. Billy Bond might give us a——

Mr. **Dean**. He is the one that made a lot of contracts.

Senator **Heflin**. He made those contracts. What arrangements, what has gone on relative to that, and what type of cooperation has existed in those research projects between various universities?

Dr. **Bond**. Well, in the agriculture program, Senator, in the Tennessee Valley region, we have continuing contracts with each of the universities in each of the Valley States since 1934. So we have been putting funds into research and development and agriculture technology since 1934.

Senator **Heflin**. That includes A&M and Auburn?

Dr. **Bond**. Yes, A&M and Auburn.

A&M—A&M has—when their charter was changed by USDA when they received responsibilities for extension work a few years ago, then that provided us an opportunity to provide more funds to A&M than we had in the past. As you know, at one time Auburn had all of that responsibility.

With regard to the fertilizer program, where the universities are working with us in the testing of new fertilizers, of early stages of development of new fertilizers and new fertilizer processes, out of the 50 universities, we contract with some 42 to 44. So since 1934 we have been placing resources into virtually all land grant universities in the United States, except in States where agriculture is not very important.

Now, in other areas, we have working agreements with a number of universities like Vanderbilt, other universities like UNA, University of Alabama, in coal mine technology, other R&D, and that kind of problems.

Senator **Heflin**. Thank you, Mr. Dean. I appreciate it.

Mr. **Dean**. Yes, sir.

[The statement follows:]

STATEMENT OF C. H. DEAN, JR., CHAIRMAN, TENNESSEE VALLEY AUTHORITY

Thank you for the opportunity to come here today and be a part of these proceedings. Our economic forecasters tell us the current recession has been harder on the Tennessee Valley region than the rest of the Nation. We are told that our prospects for economic recovery are good, but that it will again be slower than the recovery of the Nation as a whole. If we are to speed up the recovery process, we must act and act fast. However, we think that a prescription for recovery is available.

The need for a resurgence of American technology to drive the economy of this country is well documented. The restructuring of much of what has been considered traditional in American industry is already underway in such basic sectors as steel, automobiles, and aluminum. These primary industries had no choice. The competition for foreign manufacturers dictates changing technology and more highly skilled workers.

Many of the primary industries in the TVA region are now maturing and their growth has slowed, in some cases dramatically. Many areas of the Valley have been particularly hard hit by the changes that have occurred and are continuing to occur. We have seen a lag or a slow shift from standardized manufacturing to a mix that features more flexible, research-intensive manufacturing, and we are suffering because such changes are not occurring fast enough. Old manufacturing jobs will not necessarily disappear rapidly, but new jobs will increasingly require a higher level of training and skills than has been the case in the past.

As the Tennessee Valley Authority has studied this problem, we have had to look at the resources available, just as we did for an earlier age 50 years ago. The region's people, and its institutions, public and private, today as was the case 50 years ago, are the basic resources that will yield the solution to these problems.

The difference is that research in our universities, and in our other public and private organizations, is much more important today than it was 50 or even 20 years ago. Perhaps most important of all is the need for cooperation; for a kind of functional integration among these various institutions, so that the output of researchers yields useful new products for industry, *and* so that the needs of researchers are met in universities and the public sector. This functional integration is especially important in the Tennessee Valley region where traditionally investments in education have lagged behind other sections of the country.

From its inception, TVA has relied on research for much of its progress. This was done by industry, universities, other government agencies, and by TVA itself. Thus, there has always been at least a limited model of cooperation among a number of diverse and interested parties which led to a useful product.

In the fertilizer research and development area, TVA has refined this cooperative model to such a point that it can contribute to the search for a national policy that will help solve our economic problems. Because of this model, TVA is responsible for over 70 percent of all fertilizer patents in worldwide use. Countless other unpatented developments have been adopted by industry and farmers.

These achievements in fertilizer research and development were not accomplished by TVA working in a vacuum. They were, and continue to be, the product of a dynamic interaction among university researchers, industry, farmers, and TVA staff. These people identify problems, and develop and test new products, processes, and markets. They are all tied together by a network of cooperative relationships and motivated by a mixture of pride and self-interest that yields enormous economic and social benefits to the Nation. This Subcommittee is uniquely able to appreciate the fact that over 80 percent of the patents granted to TVA in fertilizer R&D are now in commercial use. I know of no other Federal laboratory that comes even close to this success rate.

With appropriate variations, this model is working. For example, like much of the upper Midwest and Eastern United States, the Valley has an abundance of low-quality and under-utilized hardwood forests. TVA, working cooperatively with other Government agencies, private industry, and universities, is searching for ways to transfer technology developed at the research institutions to the marketplace so that this resource can be put to use.

One of these efforts involves TVA staff at Muscle Shoals, Alabama, working with a process originally developed by TVA and the Forest Service's Forest Products Research Laboratory to convert trees into ethyl alcohol.

Still working with the Valley forest resource, TVA is trying a rather unusual process to transfer technology developed by TVA to the landowners and timber producers of the Valley. A very recently incorporated Forest Resources Systems Institute has established its headquarters in Muscle Shoals, Alabama. This institute, a cooperative effort of Government, Valley universities, and private industry, will distribute, service, and enhance computer-based forest management systems originally developed by TVA. The institute will provide the technology transfer function and will allow TVA to turn its resources toward solving new problems and developing additional technology.

TVA's experience seems to be well borne out by the studies of others. There must be interaction and cooperation between those doing the research and those developing and marketing the products or services if the maximum innovation is to occur. Since most of the research done in the U.S. is carried on in universities, the concept of a research park is important as one tool for assuring the appropriate interaction and cooperation.

A recent Batelle study indicates that research/industrial parks associated with strong university science and engineering programs are most likely to be successful. As would be expected, success breeds success. Additional firms are attracted, allowing more interaction among the technical and business sectors. New firms are formed as innovators and entrepreneurs see opportunities in venture capital, and in other business support mechanisms, to commercialize the products and processes developed by research laboratories. The effect is increased employment, higher income, and general economic growth.

But not every region or local community has a strong science and engineering program, nor does every research park have the other well-known characteristics that any good industrial site must have, particularly if it is to attract and hold high-technology businesses. However, these deficiencies can be overcome. One of the best examples of a successful research park in the TVA region and in the Nation is found in Huntsville, Alabama. The Cummings Research Park was started in 1952 on a 1,200 acre tract. At the present time, 36 firms are located in the park, with total employment of 11,500, and more growth is underway. A recent 800-acre expansion of the park will ensure future opportunities for high-technology growth in Huntsville. The close and productive relationship between Federal Government installations, the University of Alabama at Huntsville, Alabama A&M University, and the Huntsville community has been the major factor in the success of this research park. As the firms grow and the research park expands, the community becomes stronger and the stage is set for the next round of growth.

In another part of the region, TVA is working closely with Tennessee officials, the University of Tennessee, and local leaders to develop a similar high-technology research corridor between Oak Ridge and Knoxville, Tennessee.

Here, the lessons learned elsewhere are being applied. The State of Tennessee, the Oak Ridge National Laboratory and other Department of Energy organizations, the University of Tennessee, TVA, and the private sector are all cooperating to develop an environment most conducive to stimulating innovation and entrepreneurship. This model can be followed elsewhere in the region as well, provided the essential ingredient of a strong engineering and science university is matched with a supportive public and private sector.

As success comes with these efforts, there will be new jobs and higher incomes, of course. But most important will be the new ideas, the new products, that will once again turn "Made in America" into a worldwide watchword.

The manufacturing jobs of the 1980s and into the year 2000 will be using new technology in new ways. They will rely on "knowledge intensive" production to a greater extent than the more labor-intensive tasks of past generations. In spite of the success at Huntsville and the hoped-for success from the Tennessee effort at Oak Ridge-Knoxville, and in spite of the success of the TVA cooperative models, the Tennessee Valley region and the Nation face serious difficulties that we must continue to attack. The most obvious of these is the necessity of upgrading scientific and engineering education and research programs in our universities. Research best suited for government sponsorship must be supported. Incentives for business to cooperate with universities must be expanded, and government research must be made available to business in ways that make commercialization profitable. Finally, we must address the region's and the Nation's need for appropriate education and training of its present and future work force.

The leadership in the Tennessee Valley is facing the fact that skills and education development are the keys to economic growth and long-term economic security. TVA is working closely with state officials, local governments, labor unions, educational institutions, and business and industry to develop new and improved training systems that will ultimately yield a more skilled and productive labor force to match the needs of our constantly evolving economy.

In a series of high-technology conferences sponsored by TVA last year, in Alabama and elsewhere in the Valley States, the recurring theme of national, state, and local leaders was that quality economic growth requires a partnership approach. The emerging economy also requires new strategies that emphasize capital investments, innovative technology, skilled labor force improvements, and stronger research and development programs in universities.

TVA's role in meeting this need is in high-technology training demonstrations and in working with government, industry, and educators to develop and implement appropriate demonstration programs. These efforts emphasize high-technology skills development in the areas of robotics, microelectronics, computer science, laser technology, and automated manufacturing systems.

Other major points of emphasis in our demonstration programs include: improving math and science, computer literacy, upgrading curricula and instructors, and developing cooperative and mutually beneficial relationships between the public and private sector. As a result of the cooperative nature of these demonstrations, the capacity to educate and train Valley residents in high-technology skills has improved, and leaders in government, industry, and education recognize the fact that their cooperation constitutes and essential element of the overall economic development strategy of the Tennessee Valley region.

TVA has learned much over the past 50 years about the process of innovation and commercialization, about creating new jobs and new technologies. This committee is on the right track. We must stimulate and support the educators, the public and the private researchers, and the business institutions that put it all together, yielding new products, more jobs, and high income.

In sum, we think that research-based industrial parks, when properly fitted to a strong university, will succeed in contributing to the coming resurgence of American industrial strength.

Senator HEFLIN. All right. Next is Dr. Osmund Fundingsland, Associate Director for Science and Technology, General Accounting Office. The General Accounting Office, of course, is the investigative arm of Congress, and they do a little auditing, but they do also program evaluations, and we are delighted that you are here.

As I understand it, GAO has recently completed a study of the cooperative procedures in existence between the Government, universities, and industries. From this you have drawn certain conclusions. I am delighted to have you with us.

STATEMENT OF OSMUND T. FUNDINGSLAND, ASSOCIATE DIRECTOR FOR SCIENCE AND TECHNOLOGY, GENERAL ACCOUNTING OFFICE

Mr. FUNDINGSLAND. Mr. Chairman, I very much appreciate the privilege of representing the General Accounting Office at these important hearings. I was very impressed with what I learned from the presentations this morning. I had not realized what a complete set of relationships exist in this area among the parties, and I am especially impressed by the attitudes and commitments of the leaders in the Federal laboratories, the academic institutions and industry in working together.

I will merely highlight my statement as requested and leave the full statement in writing for the record. Before getting into the substance of my statement I would like to say just a word about why we undertook this assignment. It long has been recognized that universities and industries are very different in many aspects—in missions, values, rewards, concerns about whether information be published or proprietary, and other factors, which make it difficult to develop cooperative institutional relationships. During the hearings that were held by your subcommittee in 1979, and also by a subcommittee of the House Science and Technology Committee, this became very clear, and also the fact that there appeared to be no detailed study anywhere in the literature that disclosed what kind of lessons can be learned from the relationships that have proved successful: i.e. what are the critical factors.

And so, recognizing the high degree of interest by the Congress and the need to study and develop some guidelines for the policymakers in Washington and also for institutional leaders that want to try to generate institutional ties, we undertook this study.

My statement today is based on the report that resulted from that assignment, and the report is entitled "The Federal Role in Fostering University—Industry Cooperation."

We selected a case study approach and picked three types of university-industy arrangements that had been in existence for some time in various locations: one, the research park concept; another one called cooperative research centers; and the third, industrial extension programs, which were somewhat modeled after the longstanding agricultural program, which had the land grant colleges involved for research and the county extension agents for technology transfer.

We believe that these three types represent a spectrum of the relationships that might come into being in a formal sense. We did not look at ad hoc arrangements or informal arrangements, like the faculty consulting on an individual basis or occasional sharing of research facilities.

We conducted 4 indepth case studies of existing cooperative arrangements, and then looked at 12 more with less thoroughness, but with enough to test the hypotheses that were generated from the first studies. The four case studies included the relationship between Stanford University and the Standord Industrial Park; the cooperative research centers at MIT (the Polymer Processing program) and North Carolina State University (the Furniture R&D Applications Institute) and Georgia Tech's Technology Extension program which was modeled in part after the agricultural system.

The 12 additional arrangements we reviewed included brief studies of 2 research parks, 7 cooperative research centers, and 3 industrial extension services. These are listed in the attachment to my statement.

Of the three types of cooperation considered, the most dramatic contribution to innovation appears to be made by research parks, which enhance university-industry interaction at the frontiers of science and the leading edge of industrial technology. The most dynamic interaction we observed was at the Stanford Research Park, where we found that the philosophy of industrial collaboration had been fully integrated into the academic mission of the university. A major consequence is that communication and rapport between academic and industrial sectors have reached a higher level than any other research park we reviewed.

This interaction increases the flow of information reflecting the research agendas of both sectors. It also increases academic sensitivity to the possible commercial utility of emerging ideas and research findings.

Another measure of success of the Stanford Research Park is its effect on regional economic development. Many large and small technology intensive firms in the Silicon Valley region surrounding the park have benefited by taking advantage of the university's research park and the industrial cooperative education program.

The Stanford success can be attributed to extremely favorable circumstances prevailing for more than two decades during the creation and early development of the research park. Although it is unlikely that such an ideal situation will emerge again, we believe that if all the critical factors summarized in our report are realized, then other research parks may emulate Stanford's success.

Cooperative research centers bring universities and industry together in jointly planned research aimed at accelerating the advance and commercial application of technology. One distinction between the cooperative research centers and research parks is that industrial members of the former may be be quite far away, not in a cluster around the university as in a research park where industrial laboratories or high technology centers are in close proximity to the university.

The research agenda of a center is usually designed to fill gaps in science related to technology which no company would be likely to support along in its own laboratories; for example, to improve scientific understanding of empirically developed processes and techniques. Although both basic and applied research may be included, the research tends to be more interdisciplinary and application-oriented than research performed in academic departments concerned with industrial scientific disciplines.

Industrial extension provides assistance to new, low-technology and fragmented industries. Industrial extension services may attract new businesses to a region, create an information resource about the local economy which may be used by local development organizations, and contribute to the productivity and economic viability of existing local businesses and industries. In most cases, industrial extension has not had much effect on university research agendas.

We found that two types of issues are associated with implementing long-term institutional arrangements—those that are generic to any form of university-industry collaboration and those specific to a particular type of collaboration. Generic issues include the need to reconcile the different objectives, values, attitudes, reward structures, and research agendas of the two sectors, and locate a source of continuing financial support. Critical factors essential to resolve the generic issues for successful collaborative arrangements of any type include:

One, commitment by both faculty and administrators at a university to orient some portion of university research and expertise toward industrial needs and opportunities;

Two, commitment by particular firms to explore and use the strengths of the university while simultaneously honoring university objectives;

Three, flexibility in the university to allow policies and organizational developments for interaction with industry that respond to industrial objectives but do not compromise the academic mission of the university nor the quality of the research.

Four, a strong leader highly respected by both the academic and industrial communities to establish and maintain the partnership.

Five, matching the physical and human resources needs and interests of both university and industrial partners; and finally, sustained sources of funding.

An example of a specific issue is the requirement that university and industry participants in a cooperative research center must agree upon a mutually acceptable research agenda, which has a generic value to all or most of the participating firms.

Research parks work best at first-tier research universities where a significant portion of administrators and faculty favor interaction with industry. Industrial participants most likely to benefit from this arrangement are high technology firms, large and small, which continue to depend strongly on technological innovation for their success.

Cooperative research centers require a university with strong departments in areas relevant to the focus of a center. Industrial participation is most successful with medium to large-sized firms which have their own research and development capacities adequate to translate the research results into commercial technological applications.

Industrial extension services are best performed by a university with a strong commitment to community public service and a technology focus to assist local, fragmented industrial firms.

Federal and State Governments have played both direct and indirect roles in creating and sustaining different university-industry arrangements. The Federal Government has played a significant role in creating and sustaining each type of institutional arrangement by providing support of basic and applied research in universities to build excellence in fields of science at the frontiers of emerging industrial technology; contract support for R&D at new spin-off high technology firms; seed money for cooperative R&D centers, as well as continuing project support through grants and contracts; and both seed money and continued funding of extension services.

Our major conclusions are that financial support alone will not assure success of any of the forms of institutional cooperation. Both the generic and specific factors that are critical for each type of arrangement must be addressed to assure well-defined objectives and expected outcomes of the collaboration; the matching of resources, needs and interests of both university and industrial partners; and institutional commitments and leadership capable of reconciling the generic differences between the universities and industrial partners without incursion on the independence of either.

Federal policy initiatives intended to foster closer links between universities and industry should relate policy objectives to expected outcomes, use the most appropriate type of collaborative arrangement; and make financial support contingent upon the willingness and ability of all partners to address the critical factors and reconcile their basic institutional differences.

Mr. Chairman, this concludes my statement, and I would be pleased to respond to questions.

Senator HEFLIN. Mr. Fundingsland, the GAO report is a very helpful document for anyone interested in the universities and Government relations and cooperation. Yesterday we had Dr. Mark Money at Texas A&M who was quoting from your report.

I just wondered what kind of responses that you have received since its release. You released it when, in May?

Mr. FUNDINGSLAND. Mr. Chairman, there is evidently widespread interest in the subject of how to establish and maintain cooperative arrangements between universities and industry. We had a tremendous response from State government officials and from the universities and other sources involved either in planning new ventures or in reviewing their present arrangements. Other individuals not directly involved, but who were aware of such planning efforts asked to have copies sent to concerned State government officials, university administrators and members of committees.

Among the insitutions which expressed particular interest are MIT, Texas A&M, the Office of Governor Robb and several universities in Virginia, Georgia Institute of Technology, University of Illinois, University of Kentucky, University of Puerto Rico, University of Calgary and Polytechnic School of Montreal, Canada, and Thompson-CSF in France. Other State university systems known to be planning new cooperative arrangements with industry are Florida, Indiana, Maryland, and Missouri.

Senator HEFLIN. If you had an existing research park and it had been successful and you were going into an expansion role by which you were enlarging your research park, do you have some suggestions or ideas that you would think would be helpful in an expansion role on research parks?

Mr. FUNDINGSLAND. I would think that the primary factor would be for the universities to build on their own excellence and cultivate industrial partners who are interested in the kind of technology that is born from their research; and also, taking advantage of nearby by research centers that have a unique expertise, such as Government research centers.

I did not mention in my statement something we also found in addition to Federal funding, to build excellence in research capabilities at universities; that is, that the location of Federal facilities, like the Marshall Space Flight Center and Army laboratories here and some of the research centers the Federal Government has placed near other universities, enhance the prospects for creating or expanding a major center of excellence.

I guess those are the key factors that I would think about for expanding one, other than making sure the critical factors for any one of them are still in place and working.

Senator HEFLIN. Are we prone sometimes to not think big enough?

I suppose in reading your report, you have come across a little bit of the idea that things went slow for a while, then all of a sudden things started snowballing, and things started moving and moving fairly fast. I do not know whether this was in your report or some of the other information that I have been reading on research parks, that sometimes things do not move fast in the beginning. Then all of a sudden they will start moving and work in a rather rapid space of time.

Mr. FUNDINGSLAND. Well, Mr. Chairman, I believe the statement that you made a little earlier is very relevant to that question, namely that technology can become obsolete, and sometimes research institutions can fade a little or not get on board on some of the emerging areas that are very promising from a technological innovation standpoint. Some examples would be when lasers first came in it took a while and then all of a sudden it ballooned. Many Government agencies and many industries and universities got involved in laser research and its applications.

More recently, it has been the biotechnology field, and we have heard this morning about the space program and a gravity-free environment, a whole new area of technology, and we do not know for sure how practical it may be or whether it is going to be cost effective. But certainly we are learning some lessons and it holds a lot of promise to be able to do things in space, or possibly in some simulated laboratory environment that will not be gravity-free, but in which we might find the clues for how to improve some manufacturing processes.

As such new areas begin to check out, more institutions will get involved and expanded effort will develop at the expense of something else that fades by comparison as long as the research budget totals are constrained.

[The statement follows:]

STATEMENT OF OSMUND T. FUNDINGSLING, ASSOCIATE DIRECTOR, SCIENCE AND TECHNOLOGY, GENERAL ACCOUNTING OFFICE

Mr. Chairman, this statement is based on GAO's report entitled "The Federal Role in Fostering University-Industry Cooperation" (GAO/PAD-83-22).

We undertook our review to develop information and guidelines which would help policymakers assess whether new or revised federal initiatives were needed and how they could enhance cooperation between universities and industry. The Chairmen and ranking minority members of the House Committee on Science and Technology and the Senate Committee on Commerce, Science, and Tranportation expressed special interest in this study and requested a GAO report.

There is evidence of growning interest in various forms of university-industry cooperation. We have received many responses to our report, including requests from individuals and institutions planning new cooperative arrangements or reviewing existing ones. There also have been announcements in the press and contacts with federal officials concerning initiatives contemplated by a number of universities with endorsement from state Government officials to establish research parks or cooperative research centers in partnership with industry.

We selected the following three types of university-industry arrangements for study: research parks, cooperative research centers, and industrial extension programs. Research parks are composed of clusters of high technology firms or their research centers that are located on or near the campus of a research university. Cooperative research centers involve a number of companies in a formal agreement to sponsor research programs at a university-based center. Extension services transfer technology from a university to potential industrial users through designated exchange agents.

We conducted four in-depth case studies of existing collaborative arrangements and followed these with briefer examinations of twelve additional arrangements.

The case studies

The four case studies included: the relationship between Stanford University and the Stanford Industrial Park; the cooperative research centers established at the Massachusetts Institute of Technology (the Polymer Processing Program) and at North Carolina State University (the Furniture R&D Applications Institute); and the efforts of the Georgia Institute of Technology (Georgia Tech) to use the extension approach to assist firms in non-agricultural industries.

We chose Stanford because it was the first university-related research park established in the United States and is widely considered the most successful. We selected MIT's Polymer Processing Program because it was one of the first cooperative research centers to be funded by a National Science Foundation (NSP) program, the Industry/University Cooperative Research Center Program (IUCRC), which has served as a prototype for current government efforts to support the creation of centers for industrial technology since 1973. We chose the Furniture Institute at North Carolina State University because it was regarded as a less successful experiment and because it provided valuable information about the factors which may lead to failure in cooperative centers even when there is government support. Georgia Tech's industrial extension program was chosen because it includes a variety of extension activities directed at non-agricultural clients. In performing the case studies, we conducted 85 interviews with university administrators, faculty, students, and key representatives from industry management and participating industrial research staff.

The twelve additional arrangements we reviewed included briefer studies of two research parks, seven cooperative research centers and three industrial extension services. These are listed in Attachment I.

FINDS

The characteristics of each type of collaboration we examined are summarized in Attachment II. Our findings include their results, their conditions for success, and government roles in fostering them. In this study, we found substantial evidence that deliberately planned long-term institutional cooperation between universities and industry can enhance technological innovation. Each arrangement (the research park, the cooperative research center, and the industrial extension) may be more or less suited to achieving particular policy objectives. However, the successful creation and continuing strength of each arrangement depend upon certain critical factors, some which are general and others specific to each type of institutional arrangement. The federal government has been involved in a variety of ways in fostering cooperative arrangements between the two sectors. We also developed conclusions germane to any new or revised federal initiatives for fostering university-industry collaboration.

Results of university-industry collaboration

It is general recognized that university-industry cooperative arrangements increase communication between scientists and engineers in the two sectors. We found that the nature and degree of communication vary greatly among the different cooperative arrangements, ranging from mutual intellectual stimulation of scientists and engineers in both sectors to more service-oriented technological assistance by universtiy transfer agents for fragmented low-technology industries. We also found that university-industry cooperation may contribute to industrial innovation by: Facilitating early recognition of significant breakthroughs in basic research which make new products and processes possible; increasing the rate at which scientific and technical knowledge is adapted by industry; increasing the availability of sophisticated facilities, equipment, and expertise to scientists and engineers in industry and universities; orienting university research more toward industrial needs and opportunities (e.g., interdisciplinary research; increasing the quality of graduate training of industrial scientists and engineers; increasing the rate of founding new businesses that exploit science and technological developments, as well as improving their capacity to survive; and increasing the capacity of backward and/or financially constrained businesses or industries to take advantage of scientific and technical developments.

Of the three types of collaboration we considered, the most dramatic contribution to innovation appears to be made by research parks, which enhance university-industry interaction at the frontiers of science and the leading edge of industrial technology. Interaction between the two sectors is enhanced through providing industrial employment of faculty consultants, adjunct faculty appointments for industrial research specialists, shared laboratory facilities, part-time employment of graduate students, special graduate courses for industrial employees, and joint research projects and seminars.

The most dynamic interaction we observed occurred at the Stanford Research Park, where we found that the philosophy of industrial collaboration has been fully integrated into the academic mission of the university. A major consequence is that communication and rapport between academic and industrial sectors have reached a higher level than in any other research park we reviewed. This interaction increases the flow of information affecting the research agendas of both sectors; it also increases academic sensitivity to the possible commercial utility of emerging ideas and research findings. Another measure of success of the Stanford Research Park is its effect on regional economic development. Many large and small technology-intensive firms have been attracted to the Silicon Valley region surrounding the park to take advantage of the unversity's research park and the industrial cooperative education program.

The Stanford success can be attributed to extremely favorable circumstances prevailing for more than two decades during the creation and early development of the research park. Stanford owned many acres of undeveloped land which were available for long-term leases but could not be sold; the federal government was rapidly expanding its funding of basic and applied research at universities; and Stanford had a leader, Dr. Frederick Terman, Dean of Engineering and Provost of the University, who was greatly respected by academic, industrial, and government sectors, and dedicated to the research park concept. Although it is unlikely that such an ideal situation will emerge again, we believe that, if all of the critical factors summarized on the next two pages are realized, then other research parks may emulate Stanford's success.

Cooperative research centers bring universities and industry together in jointly planned research aimed at accelerating the advance and commercial application of technology. The research agenda of a center is usually designed to fill gaps in science, related to technology, which no company would be likely to support alone in its own laboratories, e.g., to improve scientific understanding of empirically developed processes and technique. Although both basic and applied research may be included, the research tends to be more interdisciplinary and application-oriented and research performed in academic departments concerned with individual scientific disciplines. Faculty and students participating in the cooperative research centers gain awareness of industrial perspectives that affect the orientation of academic programs. Universities involved in such centers also make substantial contributions to improving the initial and continuing education of industrial scientists and engineers.

Industrial extension provides assistance to new, low-technology, and fragmented industries. Industrial extension services may attract new businesses to a region, create an information resource about the local economy which may be used by local development organizations, and contribute to the productivity and economic viability of existing local businesses and industries. In most cases, industrial extension has not had much effect on unversity research agendas.

Conditions that foster successful collaborative arrangements

We found that two types of issues are associated with implementing long-term institutional arrangements—those that are generic to any form of university-industry collaboration and those specific to a particular type of collaboration. Generic issues include the need to reconcile the different objectives, values, attitudes, reward structures, and research agendas of the two sectors; and locate a source of continuing financial support. Critical factors essential to resolve the generic issues for successful collaborative arrangements of any type include:

Commitment by both faculty and administrators at a university to orient some portion of university-research and expertise toward industrial needs and opportunities; commitment by participating firms to explore and use the strengths of the university while simultaneously honoring university objectives; flexibility in the university to allow policies and organizational developments for interaction with industry that respond to industrial objectives but do not compromise the academic mission of the university; a strong leader highly respected by both the academic and industrial communities to establish and maintain the partnership; matching the physical and human resources, needs, and interests of both university and industrial partners; and sustained sources of funding.

An example of a specific issue is the requirement that university and industry participants in a cooperative research center must agree upon a mutually acceptable research agenda.

Each specific collaborative arrangement draws upon different strengths and resources of university and industrial participants and is not likely to succeed unless universities and firms possessing particularly relevant strengths and mutual interests are involved.

Research parks work best at first-tier research universities where a significant portion of administrators and faculty favor interaction with industry. Industrial participants most likely to benefit from this arrangement are high-technology firms which continue to depend strongly on technological innovation for their success. Cooperative research centers require a university with strong departments in areas relevant to the focus of a center. Industrial participation is most successful with medium to large sized firms which have their own research and development capacities adequate to translate the research results into commercial technological applications. Industrial extension services are best performed by a university with a strong commitment to community service and a technology focus to assist local, fragmented industrial clients.

Government roles in university-industry collaboration

Federal and state governments have played both direct and indirect roles in creating and sustaining different university-industry arrangements. The federal government has played a significant role in creating and sustaining each type of institutional arrangement by providing: Support of basic and applied research in universities to build excellence in fields of science at the frontiers of emerging industrial technology; contract support for R&D at new spin-off high technology firms; seed money for cooperative R&D centers as well as continuing project support through grants and contracts; and both seed money and continued funding of extension services.

CONCLUSIONS

Financial support alone will not assure success of any of the forms of institutional cooperation. Both the generic and specific critical factors for each type of arrangement must be addressed to assure: Well-defined objectives and expected outcomes of the collaboration; the matching of resources, needs, and interests of both university and industrial partners; and institutional commitments and leadership capable of reconciling the generic differences between universities and industrial partners without incursions on the independence of either.

Federal policy initiatives intended to foster closer links between universities and industry should: Relate policy objectives to expected outcomes; use the most appropriate type of collaborative arrangement; and make financial support contingent upon the willingness and ability of all partners to address the critical factors and reconcile their basic institutional differences.

Mr. Chairman, this concludes my statement.

ATTACHMENT I.—*Case studies which we examined briefly*

Research parks	Cooperative research centers	Industrial extension services
Research Triangle Park of North Carolina.	California Institute of Technology's Silicon Structures Project.	Industrial Extension Service of North Carolina State University.
University of Utah Research Park.	Rensselaer Polytechnic Institute's (RPI) Center for Manufacturing, Productivity and Technology Transfer.	Pennsylvania Technical Assistance Program (PENNTAP).
	University-Industry Cooperative Research Program in Computer Graphics and CAD/CAM [1] at RPI.	Texas Engineering Extension Service, The Texas A&M University System.
	Center of University of Massachusetts/Industry Research on Polymers [2].	
	University of Delaware's Center for Catalytic Science and Technology.	
	Ohio State University's Center for Welding Research [2].	
	Empire State Paper Research Institute.	

[1] Computer-aided design and computer-aided manufacturing.

[2] These were the only two arrangements we did not visit. We interviewed program directors at a conference sponsored by NSF.

ATTACHMENT II.—*Characteristics of 3 types of university-industry arrangements*

Type of arrangement	Modes of interaction	Major outcome	Critical factors	Federal involvement
Research parks ...	Research cooperation on frontiers of science and technology. Informal interaction. Increased sharing of research facilities and participation in consulting, seminars, and continuing education.	Increased communication and intellectual stimulation of both sectors. Early recognition of commercializable research and acceleration of innovation process. Improved training of industrial scientists and engineers. Enhanced regional and local economic growth.	University commitment to industrial interaction. Good fit between university and industrial strengths and research orientations. Reconciliation of research objectives, values, and reward structures. Strong leadership in academic institution.	Funding of university research. Contract support for spinoff firms.
Cooperative research centers.	Joint research planning and execution. Faculty and student participation in research centers.	Improved coordination of university and industrial research. Research outcomes oriented to industrial needs and unlikely to be done otherwise. Improved education and training for students preparing for industrial careers.	Research focus conducive to multiple firm involvement. Research expertise and equipment at the university. Strong leadership and commitment of all participants. Sophisticated R&D in participating firms. Active participation by both sectors.	Planning grants and seed funding. Project and instrumentation support. Legislative authorization of Federal assistance for new centers.
Industrial extension services.	Information transfer and consulting by university transfer agents. Workshops, classes.	Increased access to technology by fragmented industry. Increased relevance of university to community. Enhanced regional economic development.	University commitment to extension. External funding. Technological focus.	Sporadic project support. Cost-sharing with State governments.

Senator HEFLIN. Well, thank you very much. We appreciate your testimony.

We will call Dr. W. R. Lucas, the Director of the Marshall Space Flight Center.

STATEMENT OF DR. W. R. LUCAS, DIRECTOR, MARSHALL SPACE FLIGHT CENTER, ALABAMA

Dr. LUCAS. I am pleased to appear before the subcommittee today to discuss cooperative activities among industries, Government and universities that could lead to very important benefits for our society. I have prepared written testimony to submit for the record, and with your permission I would like to summarize that testimony orally.

I am a strong believer that our national future depends on the continuing strong technology initiative. We live in a very competitive world and technology provides the competitive edge, in fact I believe about the only competitive edge that we still enjoy as a nation. That technological innovation is a major contributor to the economic well-being of a society has been demonstrated throughout the history of our country.

Agriculture is one of our oldest and most successful technological industries. In the mid-1800's I am told that a farmer could feed only himself and two or three others. But the 1980 farmer fed 65 people at home and abroad. That productivity increase was brought about by technology. And so it has been with virtually every other successful industry.

Since 1945, technology has blossomed on fronts far too numerous to mention in the short time available to us this afternoon; for example, computers, electronic devices, chemicals, pharmaceuticals, communications, transportation, and robotics. The first communications satellites were flown less than 25 years ago without much thought of what would happen in these years later, and today there is a satellite communication industry representing an $8 billion investment with about a $3-billion-per-year gross revenue return.

The computer industry, which is so very critical to our economy, was not thought of a few decades ago. And yet, these technologies have been woven into the very fabric of our life to the extent that we are now inclined to take them for granted.

I think it is unfortunate that the worldwide advantage that our country, the United States, once enjoyed in many high-technology areas is being eroded as other countries push ahead. We must reverse this trend with all haste, and this reversal will require a strong cooperative effort by industry, universities, and governmental agencies at all levels. One of the strong contributors, I believe, to reversing this trend is the concentration of talent we often call research parks. I am aware that your committee has already heard testimony from some representatives of very successful research parks, but I want to direct your attention to one of high technology right here in the north Alabama region.

In Huntsville and Madison County, there is an established highly experienced partnership of high-technology activities not duplicated elsewhere in the region. This dynamic partnership is principally between the occupants of Cummings Research Park, two State universities—Alabama A&M University and the University of Alabama in Huntsville—and three important Federal research and development agencies, the Marshall Space Flight Center, the Army Missile Command, and the Army's Ballistic Missile Defense Systems Command.

The accumulation of these sources in one location provides a broad base of research capability to stimulate technological innovation and industrial growth. For example, in this north Alabama situation research programs can be implemented successfully, ranging from the very fundamental aspects of knowledge to applied research such as the development of manufacturing techniques for increased productivity. Incidentally, this later one is one that, in my judgment, has been sorely neglected in our economy.

We at the Marshall Space Flight Center are proud participants in this unique partnership as both a user and developer of high technology. We have within our own work force some 2,000 engineers and scientists and an annual budget of approximately $1.8 billion. We spend more than $416 million of those dollars in the local community.

I have listed in the testimony certain historical activities of the Marshall Space Flight Center, and the types of programs that we have been involved in, what we are involved in today and what we expect to be involved in in the future. But the important emphasis I would like to make to your committee is that we would not have been successful in the past and we will not be successful in the future without the active support of our high-technology based community.

The Cummings Research Park that you have heard about already, grew largely out of the need for industrial support for our Saturn rocket program that took man to the Moon. Today, many years later, we still continue to depend upon the companies located in that concentration. The very talented people who work for these high technology companies do a broad spectrum of activities for Marshall Space Flight Center, such as: Complicated analyses: design, manufacture, and assembly of flight hardware; and various types of research. They employ some 1,100 people specifically for these tasks done on behalf of the center.

The third very important leg of this partnership is the university system. The university system provides a pool of talented graduates from which we draw. It also, though, and very importantly to us, assures our employees the opportunity to further their professional development through graduate programs while still pursuing their daily jobs.

In the case of engineering as well as other fields mentioned earlier today, obsolescence comes upon you rather quickly, and it is necessary for our engineers to renew themselves on a frequent basis. The close proximity of the university is important not only in that regard, but also because it supplies us a research capability which is vital to our activity.

Throughout its history, NASA has recognized the importance of universities to its activities and has continued to support universities with grants and contracts. For example, the Marshall Space

Flight Center provided last year more than a million dollars to local universities for research.

Now, there is room for continued growth and expansion in this field. As universities improve their research programs and their faculties, and local high technology companies increase their capabilities, the research park becomes stronger in its influence on the local economy. Research parks attract new and sometimes small industries which are usually more aggressive and innovative, and this kind of success begets other success and consequently impacts the local economy.

We recognize that today's world and high technology is very competitive. Simply to have a few industries and a university and some Government laboratories is not enough. The local environment has to be concerned about other things, such as secondary and primary schools, local government, investment incentives, business and cultural environments. And these things are important to the growth and nurturing of high technology centers.

This north Alabama area can, in my judgment, be one of those important research areas. The ingredients are all here. And I believe there is a commitment among the citizens of this location to work to that end, because they recognize that technology cannot be forced, it cannot be legislated, it must be fostered.

I believe that your distinguished committee and most Members of the Congress appreciate the importance of technology, and I hope the Congress will commit itself to fostering the growth of high technology centers nationwide. In my judgment, it is the wisest investment we can make to the future of our Nation.

Now, in closing, Mr. Chairman, I would like to refer very briefly to the very successful flight of the Space Shuttle involving the European Space Agency and National Aeronautics and Space Agency Spacelab in the last few days. The mission is scheduled to end tomorrow morning at 9:58 a.m. This mission is a product of the collaboration of Government, industry, and universities on two different continents, and undoubtedly, from what I hear of the results coming from that mission, these results will stimulate additional research.

One of the most promising possibilities from utilizing the space environment may involve materials processing in space. Based upon the results of very limited experiments accomplished in past missions, it appeared that research on materials in the zero-gravity environment could greatly improve our knowledge and understanding of materials behavior, both in the space environment and on Earth.

The knowledge gained from doing materials processing experiments in space was expected to contribute significantly to our understanding and application of ground-based processes. Furthermore, it appeared that there might be technical and economic benefits to actually producing materials in space for use on the ground.

With this as a background, on Spacelab 1, the one now in flight, a total of 32 materials processing experiments are being conducted to investigate the effects of the low gravity environment of space on: The solidification of metals and alloys, the growth of semiconductor crystals, the production of glasses; and doing some fundamental studies on fluid physics which are employed in many materials processes. Preliminary results from these experiments, as I understood from a scientist when I visited in Houston on Monday, are very encouraging.

I believe that a research park would be an excellent setting for nurturing a center of excellence in materials processing in space that could grow to a very productive venture. I have provided for the committee and have copies for others, four publications of the Marshall Space Flight Center and NASA, which indicate some of the possibilities in our judgment for commercialization. These are "Metals, Alloys and Composites," "Chemical Products and Biological Preparations," "Semi-Conductors and Electrical-Optical Materials," and "Containerless Processing in Low Gravity." These are available for any of you who may wish to receive copies.

Mr. Chairman, that concludes my oral testimony and I will be pleased to respond to questions.

Senator HEFLIN. Well, thank you, Dr. Lucas. We appreciate it very much.

We are all vitally interested in your history and it certainly is a history of cooperation and interaction of the private sector and Government in the space program. There has been a tremendous amount of that, plus the interaction with the universities in trying to work on basic concepts.

And I gather that the community here has benefited. There is an interchange of people who have retired from our space agency who have gone over to UAH or to Alabama A&M and become professors or teachers, some on a part-time basis. And there may be programs that have been designed where some of their students could do cooperative work with your program. And would you like to elaborate a little bit on that type of thing?

Dr. LUCAS. Yes, sir, I would be pleased to. There has been a very positive and effective collaboration between the local universities—and when I say "local universities" I refer to the University of Alabama in Huntsville, Alabama A&M, and also include in that Auburn University and the University of Alabama at Tuscaloosa, and to a much lesser extent with the University of Alabama in Birmingham.

There has been, particularly for those in the Huntsville area, there has been an interchange of faculty. Faculty have been afforded the opportunity to work in our laboratories where we had certain equipment that they did not. Our people have worked in the university campus, and there has been a very positive stimulating kind of interchange between the researchers involved, utilizing I believe to a maximum extent the joint facilities that we hold.

Senator HEFLIN. We are very much interested in materials processing and the material you have given us to read. Mr. Wood, who testified earlier, has done work for NASA in space. He listed some examples of what could be done.

It may be that you might even want to enlarge on these areas that you see interest from industry working in zero gravity to accomplish certain things. Would you like to give us just off the top of your head—I am sure you do not have a list or something like that—some of the things that you see of interest to industry and some things that would be of interest to generally the people in this area?

Dr. LUCAS. Yes, sir, I would be happy to comment on that. I happen to believe, based upon the very preliminary results that we have obtained over the years, that research in materials processing in space may be one of those things that blossoms, as communication, meteorology, and other things of that nature have profited by using the space environment.

It seems to me that the foremost initiative at the moment is a joint venture that is being done with McDonnell-Douglas Co. and Ortho Division of Johnson & Johnson—a joint venture with NASA in which no money is exchanged. The companies make the investment in the facilities, and NASA flies it and we exchange information.

This is a process called electrophoresis, a process that is greatly enhanced by the low gravity of space and which enables one to separate pharmaceuticals or chemical substances that are very difficult to separate on the Earth, but can be separated in such a way that these products seem to be more useful for the treatment of various diseases. The company has already spent a substantial amount of money and has flown this experiment some three or four times, and will be flying it additional times. I think this represents a very important initiative and one that I believe will pay dividends in the future and one that other people interested in medical and pharmaceutical research should become involved in.

There is another joint venture with Microgravity Associates, that is less advanced, in which they expect to do some research involving primarily crystal growing, and I believe that has potential, also.

We have worked with companies locally for ground-based research in a joint venture basis. And we normally think of those things that would be attractive to doing in space as those things that are low in volume and very high in values. Sometimes we are surprised at what can come from this pattern of research. For example, we have had a joint program with the John Deere Co. working on cast iron which has been used for many years, and which one would think would be throughly understood. Yet, using some of our facilities, specifically the drop tower at the Marshall Center where we can get some 4 seconds of zero gravity, they have been able to learn some things about cast iron that they did not know before. This will affect the products that they are able to produce here on Earth.

We have a similar arrangement with the International Nickel Co., where there is working on certain alloys that they believe they can learn more about by working in the low gravity.

Still another relationship is with the DuPont Co. They are working with some alloys, also in low gravity, which can be used for making catalysts for enhancing chemical reactions.

So these are some things where people have already gotten a vision of the future. And just as the cast iron activity might be unanticipated, I believe when we move out of this environment, when we have the opportunity now provided by the shuttle and the spacelab, that people are going to discover things that they have never even dreamed of.

For example, when the Echo balloon was launched some 25 years ago, which was a passive object that off of which we bounced signals, who would have believed that less than 25 years later we would have a communications industry that we could hardly do without today. I believe this same kind of thing is available to us in materials processing in space. I am looking forward to that development here.

Senator HEFLIN. Do you think in order to expedite this that there are certain resources that are needed to expand this—greater appropriations—or is it a matter of sort of a catalytic agent? Is it going on schedule, or on the other hand is it perhaps maybe that the space station may be getting off into some question of priorities? In the materials processing, if it has a great future, what do you foresee as the catalyst in bringing it about sooner?

Dr. LUCAS. Well, I believe, sir, that we are right on the threshold of demonstrating that capability. We have not had a lot of opportunities in the past. We have used the drop tower at Marshall for about 4 seconds. We have used the low-G aircraft, which gave us about 30 seconds of low gravity. We have used a rocket, a sounding rocket, which gave us 5 or 6 minutes with low gravity.

But now, with the spacelab just on its first mission, we are on the verge of demonstrating that potential in a way that is going to stimulate and drive this particular technology. For example, this first one has rather fundamental studies on it, many of which are European—most of which are European in origin. But the next spacelab, to be flown a little less than a year from now, will be devoted almost exclusively to materials processing in space, and I believe the results to be obtained from that flight and succeeding flights are going to stimulate interest.

I believe that we are going to have to continue to apply some resources to materials processing in space, perhaps more resources than we have applied up to this point. But I believe that in a short period of time, 2 or 3 years, we will have demonstrated enough interest to industry that they will be willing to provide some venture capital in to further stimulate the growth of this area.

We can do the job with the spacelab in the nearing years; but obviously, if this field grows to the extent that I believe it will, a continuing presence in space—a space station will be required. So I believe the space station is the next step.

Senator HEFLIN. Is it possible that on Earth you could build a chamber in which you would have a simulated zero-gravity atmosphere? Can you develop on Earth a place where you could do the material processing without having to go into space? Are there prospects of developing it here on Earth? You seem to have done it in 4 seconds with a drop tower.

Dr. LUCAS. We have to have a very high drop tower to get more than that. The drop tower is about 300 feet tall and we get about 4 seconds. We get about 30 seconds by flying the parabolas on aircraft; that gives us 30 seconds. And we have gotten 5 or 6 minutes with the sounding rocket.

I do not believe it is practical to go much beyond this. The vacuum of space can be simulated here on the ground; we can get a vacuum that is adequate for most of our needs. We cannot do this with zero gravity, and therefore I think we are obliged to use space for that.

I believe we can learn some things in the zero gravity of space that will enable us to improve the products that we are producing here on Earth. The knowledge that we gain in space can be applied on Earth, but I believe by the same token that there will be some things that we must do in space, if we are to do them all.

Senator **Heflin**. Do you have some thoughts on this bill that we have—that Senator Gorton and I and others have introduced? If you have some suggestions pertaining to improving it, really, it is a skeleton bill, as everybody realizes, and we are holding hearings to hopefully flesh it out.

Dr. **Lucas**. Senator, I will be pleased to comment on the bill as an individual. NASA has not had an opportunity to study the bill and take a position on it, but I will be pleased to comment on it as an individual if that is satisfactory.

Senator **Heflin**. Sure.

Dr. **Lucas**. I have read the bill. I strongly support the thrust and content of that bill. I believe it represents a consideration of a much neglected area of research in this country. We often comment on the preeminence of our research programs and the technology we have developed. But unfortunately, we have not applied that technology uniformly.

It is relatively easy to see, it seems to me, to get research for very basic, fundamental things. It is exciting to work in the unknown. On the other extreme, we can usually get support for make-work situations when we have a project which is in trouble. But there is a big gap in the middle. There is an important area of manufacturing and processing technology that in my judgment has not been adequately supported, and I believe that that area offers one of the greatest potentials for increasing productivity of our country.

I personally have experience in cases where we are applying the latest in technology to the design and yet the comparable technology in manufacturing to produce that something leaves a lot to be desired. I believe there is a great deal to be gained in manufacturing process research. I think it has one of the greatest potentials of increasing the productivity of our country more than anything else I can think of.

I am aware of some examples where we have tried process improvement based upon research from the Marshall Space Flight Center. For example, I recall of two areas where we had a research program dealing with processing that will save over a half-million dollars per flight on each shuttle flight.

I believe there is a potential for significant payoff, and whereas NASA is not taking a position on this. I, as an individual, being personally experienced in this area, believe it to be an important initiative and I support it.

[The statement follows:]

STATEMENT OF DR. WILLIAM R. LUCAS, DIRECTOR, MARSHALL SPACE FLIGHT CENTER

Mr. Chairman, I am pleased to appear before the Subcommittee today to discuss cooperative activities among industries, universities, and government that could lead to innovation and new technology. I believe that our national future depends on a continuing strong technology initiative. We live in competitive world and technology provieds a competitive advantage—in fact, about the only competitive advantage we still enjoy as a nation.

That technological innovation is a major contributor to the economic well-being of a society has been demonstrated throughout the history of our country. Agriculture is one of our oldest and most successful technological industries. In the mid-1800's, a farmer could feed only himself and two or three others. The 1980 farmer fed 65 people at home and abroad. That productivity increase was brought about by technology. So it has been with virtually every other successful industry. Since 1945, technology has blossomed on fronts too numerous to mention in the short time available this morning; for example, computers, electronic devices, chemicals, pharmaceuticals, communication, transportation, and factory robotics. The first communications satellites were flown less than 25 years ago and today there is a satellite communciation industry representing an 8 billion dollar investment with an annual gross revenue of approximately 3 billion dollars. The computer industry, which is now so crucial in our economy, and solid state electronics are products of the last few decades, yet these developments have been woven into the very fabric of our daily lives and, to a great extent, are taken for granted to the same extent as is the farmers' increased productivity. It is unfortunate that the worldwide competitive advantage that the United States once enjoyed in many high-technology areas is being eroded as other countries push ahead. We must reverse this trend with all haste, and this reversal will require storng cooperative efforts by industry, universities, and governmental agencies at all levels.

As the national discussion progresses on how to achieve such a reversal, the most frequently mentioned models of high technology initiatives are research parks. The three parks usually discussed are located in the Research Triangle in North Carolina, Silicon Valley near San Jose, California, and along Route 128 in Boston, Massachusetts. These successful research parks and others have played an important role in stimulating technological innovation and economic growth of high technology in their regions. While much could be learned by considering these success stories, I want to direct your attention to the growth of high technology in the north Alabama region.

In Huntsville and Madison county, there is an established, highly-experienced partnership of high-technology activities not duplicated eleswhere in the region. This dynamic partnership is principally between the occupants of Cummings Research Park, two state universities (Alabama A&M University and the University of Alabama in Huntsville) and three important federal research and development agencies (the Marshall Space Flight Center, the Army Missile Command, and the Army's Ballistic Missile Defense Systems Command). The accumulation of talent from these sources on one location provides a broad base of research capability to stimulate technological innovation and industrial growth. For example, in this North Alabama situation, research programs can be implemented successfully ranging from the fundamental aspects of knowledge to applied research such as the development of manufacturing techniques for increased productivity.

We at the Marshall Center are proud of our participation in this unique partnership, as both a user and developer of high technology.The Center has within its workforce about 2,000 engineers and scientists, and has an annual budget of more than $1.8 billion. We spend more than $416 million of that in the local community for salaries, goods and services, and on research and development.

Historically, the Marshall Center has been known for its role as developer of NASA's rocket propulsion systems from the Jupiter C rocket that lifted America's first astronaut, Alan Shepard, into space almost a quarter of a century ago, to the sophisticated propulsion system for the Space Shuttle.

The Center has also established a reputation as a developer of space experiments, both large and small. We have had experiments aboard most of the Shuttle flights to date including a full Shuttle Payload, Spacelab, launched just nine days ago. We have primary responsibility for development of Space Telescope, and we are developing some 40 to 45 experiments for flight on future Shuttle/Spacelab missions.

Looking to the future, we are studying concepts and developing required technologies for a potential space station, advanced launch vehicles, and future Shuttle payloads. All of our flight experiments require the latest in hardware and software technology.

In addition to our flight activity, we are engaged in substantial laboratory research for our own utilization as well as to transfer technology to the private sector. But we would not have been, and will not be, successful in our endeavors without the active support of our high-technology based community.

Cummings Research Park grew largely out of the need for industrial support for our Saturn rocket program that took man to the moon. Today we continue to depend on the companies located there. The talented people who work for the high-technology firms of the Park participate in a broad spectrum of MSFC activities such as complicated analyses, the design, manufacture and assembly of flight hardware, research in solar physics, the integration of multiple experiments for flight on the Space Shuttle; and reduction of data from both flight and ground experiments. To accomplish our tasks alone, these companies employ nearly eleven-hundred people from the Huntsville area.

The local university system is the third leg of this important partnership triad. It not only provides a pool of talented graduates from which to draw, but it also assures our employees the opportunity to further their professional development through graduate programs and provides us with a valuable, local research capability. The close proximity of a university with strong research capabilities is vital to a successful research park, a NASA Center or any other high technology enterprise.

Throughout its history, NASA has recognized the importance of universities to its activities and has continued to support universities through contracts and grants. The Marshall Space Flight Center provided more than a million dollars to local universities for research last year. As the local universities continue to develop and expand their research capabilities, there is opportunity for much growth and expansion. The same principle applies to commercial firms; it is imperative that local companies involved in research and development become more capable and competitive to increase their success in acquisition of high technology assignments. As universities improve their research programs and local high technology companies increase their capabilities, the research park becomes stronger in its influence on the economy.

Today's competition for space and other high-technology dollars is intense. For an area to compete effectively, it must develop and strengthen those inducements that attract and facilitate high-technology (industrial as well as government sponsored). One of those inducements, in addition to universities with strong programs in science and engineering at the graduate and undergraduate levels, is educational opportunities in elementary and secondary school systems. Obviously, there are other inducements to the growth of high technology—investment incentives, business and cultural environments, local government, transportation, and a safe, pleasant place to live—to name a few. I am confident that the future is dependent upon new technology development. I am equally confident that more centers of technological excellence will spring up around the country and that these centers will be the hubs of the economy.

This North Alabama area can be one of those—all of the ingredients are here—including, I believe, the commitment to work to that end because it is recognized that technology cannot be forced. It must be fostered. I believe that your distinguished committee and most members of the Congress appreciate the importance of technology, and I hope the Congress will commit itself to fostering the growth of high technology centers nationwide. It is the wisest investment we can make in the future economy of our nation.

The very successful flight of the Space Shuttle with the ESA/NASA Spacelab in the last few days is a product of the collaboration of government, industry, and university. Undoubtedly, the results of experiments conducted on this mission will challenge additional research.

One of the most promising possibilities for utilizing the space environment may involve Materials Processing in Space. Based on the results of very limited experiments accomplished on past space flight missions, it appeared that research on materials in the zero-g environment could greatly improve our knowledge and understanding of materials behavior both in the space environment and on earth. Knowledge gained from doing materials processing experiments in the space environment was expected to contribute significantly to our understanding and application of ground-based processes. Furthermore, it appeared that there may be technical and economic benefits to actually producing products in space for use on the ground.

On Spacelab 1 (now in flight) a total of 32 materials processing experiments are being conducted to investigate the effects of the low gravity environment of space on the solidification of metals and alloys, growth of semi-conductor crystals, and production of glass. Other related experiments are in progress which will lead to a better understanding of fluid physics. Preliminary results of the experiments are very encouraging. A research park would be an excellent setting for nurturing a center of excellence in Materials Processing in Space that could grow to a productive venture.

Mr. Chairman, this concludes my testimony, and I wish to thank your Subcommittee for the opportunity to appear today.

Senator **Heflin**. Well, thank you, sir.

All right. We will have Dr. Bruce Reese, deputy commander of engineering for the ballistic missile defense program.

STATEMENT OF DR. BRUCE REESE, DEPUTY COMMANDER OF ENGINEERING, BALLISTIC MISSILE DEFENSE SYSTEMS COMMAND

Dr. **Reese**. Mr. Chairman, I am representing Brig. Gen. Eugene Fox, who is the deputy ballistic missile defense program manager in Huntsville. General Fox is out of the country and regrets his inability to appear before you.

I appreciate the opportunity to testify at the hearing to explore cooperative activities among industry and Government that could lead to innovation and new technology. From the perspective of a former professor, I commend your interest in illuminating these interactions. Much, of course, of what I would say has already been said by Dr. Lucas and General Bunyard.

We work in the same general area, we have many of the same technology problems. I would like to make some statements that are somewhat different, related of course, but somewhat different, on the efforts that have gone on over the years in ballistic missile defense in the area of high technology and innovation.

The ballistic missile defense program has been synonymous with high technology and innovation since its inception in 1955. Many experts thought ballistic missile defense was impossible. The idea of launching missiles to shoot down strategic nuclear missiles reentering the atmosphere at 4 miles per second was akin to hitting a bullet with a bullet, and was therefore one of the things you sneered about because it was so difficult.

Technological difficulties would have to be rolled back and they have been, in radar, data processing, and missiles themselves. I find, somewhat to my surprise, that there are still groups that say that ballistic missile defense is not technologically plausible. There was a recent study done by Harvard by a nuclear group that came to that same conclusion.

For three decades the ballistic missile defense program has kept the United States qualitatively ahead of the Soviet Union due to ballistic missile defense technology. Today, the fourth generation of missile defense technology is maturing, and they point to the feasibility of President Reagan's hopeful vision of rendering the threat from strategic nuclear missiles obsolete and developing a strategy of mutual survival rather than mutual destruction.

As you have noted in your correspondence with the President and on the Senate floor, work is also underway on an even newer generation of technologies for strategic defense, including technologies for the directed energy weapons, such as lasers and particle beams, which rightly capture our imaginations.

Spinoffs from ballistic missile research and development have enhanced a long list of efforts by the Government in realms of radar, optical sensors and missile technology, materials and structures. The ballistic missile defense program's work in sensors and data processing developments, particularly in the area of computer software engineering, have found industrial applications. Analytical techniques developed by ballistic missile defense have been adopted by the medical community and the nuclear power industry.

On this record, which I have sketched only briefly, ballistic missile defense organization in Huntsville has become known as the free world's center of excellence in strategic defense technology. The question pertinent to your hearing is: How does one go about achieving and maintaining such a record?

And we have talked a lot about that today. I think one of the things that I would mention is that there must be a need. We have had a requirement for high technology, and that technology has been a constant growing one so that the need has ever increased, and it has driven the BMD program for nearly three decades.

The second thing which we have had, which has been supplied by the Congress, is money and a work force. Now, the work force consists of a dedicated and I think extremely able Government force. It has been assisted then by an extremely able university group and an extremely able and long-term industrial group.

Within the ballistic missile organization we have had that outstanding work force and the continuing funding for these three decades, and I think that has been a very large item in sustaining and maintaining this technological group that we have which consists of all the Government. And the Government, of course, takes all the credit, but most of the work is done by the university and the industrial people.

We have these things organized, then, into two organizations. I think in addition to the work force you must have an organization. We have an organization which supports, then, technology. We have one called an advanced technology program, and then we have another one which is called the systems technology program.

The advanced technology program pursues research and development of new, emerging, and potentially revolutionary technologies for future ballistic missile defense systems and for improvements to near-term ballistic missile defense systems. The products of the advanced technology program are the building blocks of the ballistic missile defense capability. When the building blocks reach sufficient—and I guess I ought to add, if they reach—maturity, they are transferred to the systems technology program, which pursues research and development of ballistic missile defense systems.

The systems technology program integrates the building blocks into candidate systems designs and validates them through laboratory and field testing and simulation. And we do it on a very large scale computer simulation. Integrating the elements of the complex system so that they work in concert and produce the desired results reliably and within the budget poses a different kind of challenge, but an equal kind of challenge to technology and innovation of its own. Ultimately, the process culminates in the demonstration of the system capability that keeps the United States in a position to deploy an effective defense if we should be so directed.

Two programs rely extensively on both industry and universities. As I have mentioned, around 25 percent of what I consider a very significant budget typically goes to companies and universities in Alabama. Most of this 25 percent, of course not all, are located in the Huntsville area.

We do work with the two local universities, Alabama A&M and the University of Alabama in Huntsville, and they include, for example, such high technology areas as "Optical Studies in Laser Dyes," "Investigation of Soft X-Ray Laser Action," "Composite Material in Rocket Motor Cases," and so on. We also do work with our sister university down in Auburn. That area is primarily in the area of advanced data processing.

Currently, we contract with 15 universities for a total of 28 contracts with an annual investment of about $5.7 billion. Most of these, all but four actually, of the contracts are in support of the advanced ballistic missile defense technology program. The four of them are a part of the systems group, and would expect that split in assistance activities.

Now, we have done some other things in addition to the support of university research. We have taken a couple of actions here to support innovation or to stimulate innovation. We had a program which ran from 1973 to 1980 known as the active search program. Its purpose was to search systematically for new technology that might revolutionize ballistic missile defense.

Its method was to seek out universities, laboratories and research companies which were outside the familiar ballistic missile family and see what they had to offer. The group assembled teams, they visited these organizations, they received briefings on the current research efforts of those groups. Specifically, the team asked what was new and exciting to the researchers, but did not expect them to make the connections between their work and the ballistic defense problems and programs. That was the search team's job.

The program identified a number of significant concepts and ideas: Data processing technology, miniaturized monolithic accelerometer, and integrated optical signal processors, physics for free electron lasers and neutral particle beams and so forth.

Nearly 300 new ideas were identified in each year of the program, and about 10 percent of those we thought were related to our efforts and were funded. We spent about an average of about $150 million per year in support of these projects, and these projects would then last from 1 to 3 years.

The small project, the average cost was $150,000 per year per project. About 30 percent of those that we did fund were continued beyond the initial investigation stage. Because they were high risk, high potential payoff programs, we felt that this would probably be the right percentage. If we found more success, we probably were not far ranging enough. If we had fewer, then we probably were a little bit tougher on those companies than on ourself.

The new Department of Defense small business innovation research program resembled in some sense this active service. The purpose is to stimulate and support small business to conduct that quality, innovative research program. Of course, the difference is we look for them, not they looking for us.

We publish a list of things we are interested in and they examine those and see whether they can interface with us. So it is the same kind of program, except one was very active, very active on our part; and this last one was more passive.

We are active supporters of that innovative research program. thirteen of the fifty phase I awards that the Army has done are in support of ballistic missile defense advanced technology work and are currently being negotiated and awarded.

While most of the formal pursuit of innovation in ballistic missile defense is conducted in the advanced technology program, the systems technology program also has an innovative system, which is called unconventional ballistic missile defense concepts. This program is interested in unconventional concepts. We have been interested in them from the beginning. We have always had a number of volunteers in that area.

We have not created a system, a group that systematically examines these and keeps records. Presently, we are investing about $2 million a year in the investigation of unconventional systems. Recently, we have rereviewed or reviewed about 40 of these unconventional systems. We have yet to find one that is not flawed, that we would like to support, although we are doing some research and some investigations on parts of these efforts. We remain available to look at unconventional systems, by whoever submits them, even if his name is Rube Goldberg.

What can be learned regarding high technology and innovation from the experiences ballistic missile defense has had? I believe that the most important lessons are those of imagination, willingness to risk, patience, and dedicated resources. Imagination is necessary to allow those of us in charge to believe that there might be something worthwhile in a scheme that is different. Willingness to risk is necessary to keep us from deterring ourselves from taking a chance because the scheme might fail. Patience is required to give something time to work if the promise exists, even when it may have failed or had a lot of difficulty.

Most important, though, are dedicated resources, both money and the work force. They prove that you are really serious about pursuing innovation in this high technology world. After all, you are trying to direct the mind and productive capability of man where perhaps none have gone before. These are expeditions that are not easy for the backer or for the adventurers, but the payoffs are worth the risk.

I appreciate the opportunity to appear at the hearing. I have some support on your staff and I have the former commander of this organization with me. So I hope that we can field your questions.

Senator **Heflin**. Well, thank you. I appreciate it.

I understand some of your work is classified. I had some briefings and found it is sort of distinctive. But I remember some of it is not classified, that some of the work you are doing with optical sensors by which you could determine whether or not certain incoming missiles are going certain places, that is an area that is not classified, is it not?

Dr. **Reese**. The fact that we are doing them is not classified, Senator. The ranges, the number of elements, the scan times, those kinds of details are classified. But the fact that we are very interested in them, that they hold great promise as adjuncts to the radar and they potentially, some day in the future, may be an independent systems, those facts are not classified.

Senator **Heflin**. I am just interested in that from the viewpoint of how research developed on optical sensors and how they developed relative to this sort of matter to illustrate what is going on in your field. I do not know whether you might want to explain a little bit.

Dr. REESE. He slept closer to that than I did. Do you want to give him a history?

Dr. REESE'S ASSOCIATE. You are on the stand.

Dr. REESE. OK. The reason I am a little reluctant here is that I have an old veteran and I have only been with this group as a full-time employee for a short period of time.

I think the optic, like the other things, are based on the ideas that they get from the university and from industry; they have capability. The company comes in and says, you know, if you give us a little money, we could work on this. And the group that have done this, I think shows a lot of imagination.

I am most impressed with the leader or director, a man by the name of Bill Davies, who has not only shown a lot of imagination, but has got a lot of guts and is a little bit pigheaded. I keep telling him that he fights too hard. He fights to get those moneys, he gets those moneys, and he has worked with those programs to produce, I think, a lot of sensors, a lot of technology.

And I personally, you know, am a little reluctant to swallow, and I think a lot of other things. But I think it is that exact process where people have ideas and you are willing to risk and you are willing to support and you have got some money. You have got to invest capital in this organization, and when there is not any it is hard to support new ideas.

The advanced technology program, you know, they always tell me they do not have enough money and they always have more places to put money than they have got money. But nevertheless, they do have a little money that they could put on the better ideas. And the optics has shown that promise, it has been demonstrated, and I have been most impressed with what they have done.

In fact, in my humble opinion, I am not aware—I am aware of classified programs, and then there is classified classified programs, and I am not aware of all of those, but I would clearly make this statement without fear of too much contradiction: that the optics work as much as the ballistic missile defense is the best in the free world. And I would suspect that that is true all over the world, because we have—the United States clearly had a stronger incentive in sensor optics, making other—the high energy lasers, the higher power sensory lasers.

[The statement follows:]

STATEMENT OF DR. BRUCE A. REESE, DEPUTY COMMANDER—ENGINEERING, BALLISTIC MISSILE DEFENSE SYSTEMS COMMAND

Mr. Chairman, I am Dr. Bruce A. Reese, Deputy Commander for Engineering of the Ballistic Missile Defense Systems Command, United States Army. I am representing Brigadier General Eugene Fox, Deputy Ballistic Missile Defense Program Manager-Huntsville. General Fox is out of the country and regrets his inability to appear before you.

I appreciate the opportunity to testify at this hearing to explore cooperative activities among industries, universities, and government that could lead to innovation and new technology. From a perspective that includes experience as head of the School of Astronautics and Aeronautics at Purdue University, I commend your interest in illuminating these interactions. However, owing to the current emphasis on research and development within the Ballistic Missile Defense Progam and because available time has not permitted sufficient study of the proposed legislation, I am unable to comment on S. 1286 regarding research in advanced manufacturing techniques.

I have a brief prepared statement which I would like to present to the committee.

The Ballistic Missile Defense Program has been synonymous with high technology and innovation since its inception in 1955. Some experts thought ballistic missile defense was impossible. The idea of launching other missiles to shoot down strategic nuclear missiles reentering the atmosphere at four miles per second was akin to hitting "a bullet with a bullet." Technological frontiers would have to be rolled back, and they were in radar, data processing, and missilery. The capability to shoot down missiles had to be invented.

As new attack-missiles capabilities have been invented, new defense capabilities have also had to be invented. For nearly three decades, the BMD program has kept the United States qualitatively ahead of the Soviet Union in BMD technology. Today the fourth generation of missile defense technology is maturing. Its optical sensors, tiny but powerful computers, and new missile guidance concepts are among the technologies which point to the feasibility of President Reagan's hopeful vision of rendering the threat from strategic nuclear missiles obsolete and developing a strategy of mutual survival rather than mutual destruction. Work is also under way on an even newer generation of technologies for stratgic defense, including technologies for the directed energy weapons, such as lasers and particle beams, that rightly capture our imaginations.

Spinoffs from BMD research and development have enhanced a long list of efforts by all the services and other government agencies in the realms of radar, optical sensors, and in missile technology, materials, and structures. The BMD Program's work in sensors has also found its way into private industry. Data processing developments, particularly in the area of computer software engineering, have found industry applications. Analytical techniques developed by BMD have been adopted by the medical community and the nuclear power industry.

On this record, which I have sketched only briefly, the Ballistic Missile Defense Organization in Huntsville has become known as the Free World's center of excellence in strategic defense technology. The question becomes: How does one go about achieving and maintaining such a record?

First, there must be a need to be met. In the case of BMD, the need is for capabilities to counter an adversary's strategic nuclear missiles. That has driven the BMD Program for nearly three decades.

Then there must be fiscal and workforce resources dedicated to meeting the need and organized to meet it. Within the Ballistic Missile Defense Organization, we pursue two complementary major programs, an Advanced Technology Program and a Systems Technology Program.

The Advanced Technology Program pursues research and development of new, emerging and potentially revolutionary technologies for future BMD systems and for improvements to near-term BMD systems. The Advanced Technology Program has been roughly constant in scope for the last six years. For fiscal 1984, continuation of this scope requires the expenditure of $170.9 million. The products of the Advanced Technology Program are the building blocks of US BMD capabilities. When the building blocks reach sufficient maturity, they are transferred to the Systems Technology Program, which pursues research and development of BMD systems.

The Systems Technology Program integrates the building blocks into candidate BMD system designs and validates them through laboratory and field testing and simulation. Integrating the elements of complex systems so that they work in concert and produce the desired results reliably and within budget poses high order challenges to technology and innovation of its own. Ultimately, the process culminates in the demonstration of US BMD system capabilities that keep the United States in a position to deploy an effective defense if the need arises. The current expenditure authorized for Systems Technology is $338 million.

The two programs rely extensively on both industry and universities. Twenty-five percent of the BMD Program budget typically goes to companies and universities in Alabama. Most, but not all, are located in the Huntsville area.

Work at Alabama A&M University and the University of Alabama in Huntsville includes such efforts in such high-technology areas as "Optical Studies in Laser Dyes," "Investigation of Soft X-Ray Laser Action," "Methodologies in BMD Technologies," "Disturbance Accommodating Control Theory for BMD Interceptors," "Approaches to Unconventional Computational Methods for Associated Parallel Array Machines," "Composite Material Motor Case A," and "Electromagnetic Accelerator

Plasma Phenomena." Work at Auburn University is principally in advanced data processing.

The Ballistic Missile Defense Organization currently has a total of 28 contracts with a total of 15 universities around the country, which represent an investment of $5.7 million. Typically, all but four of the contracts are in support of the BMD Advanced Technology Program. The work done by universities characteristically speaks more to the needs of the Advanced Technology Program than to those of the Systems Technology Program. Most universities are more attuned to theoretical and analytical studies and experimentation on a relatively small scale than to hardware development and testing with an eye toward producing and deploying a system.

From 1973 through 1980 the Advanced Technology Program conducted an effort most recently known as the Active Search Program. Its purpose was to search systematically for new technology that might revolutionize BMD. Its method was to seek out universities, laboratories, and research companies which were outside the familiar BMD community. A search team was designated from members of the BMD Organization, consultants hired from non-competing companies and institutions, and from other Government elements such as the Office of the Director of Defense Research and Engineering. Approximately quarterly the team made a week-long series of visits, describing the BMD Program very generally and then being briefed on the current research efforts of their hosts. Specifically, the team asked what was new and exciting to the researchers but did not expect them to make the connections between their work and BMD; that was the search team's job. (In fact, the researchers gained insight into BMD as a result of interaction with the search team, and a number of them subsequently suggested further ideas.) After each visit, the information collected was evaluated and recommendations were made to the appropriate element of the BMD Organization or to another Government agency regarding ideas that merited follow-up.

The program identified a number of significant concepts and ideas, which could lead to significant improvements in cost, effectiveness, and development time. A host of advances identified in data processing technology, taken together, added up to a revolutionary advance. Significant advancements also evolved in several other areas: For example, a miniaturized monolithic accelerometer, and an integrated optical signal processor, and physics for free electron lasers and neutral particle beams.

Nearly 300 ideas a year were identified during the program and about ten percent of those funded. Records for the last four years of the program indicate that an average of about $1.5 million a year was invested in projects that lasted one to three years and averaged approximately 30 a year in number. Average cost was $50 thousand per year per project. About 30 percent of those funded were continued beyond the ASP investigation stage. Because they were high-risk, high-potential-payoff projects, a higher success rate probably would have indicated the team was being too conservative either in where it looked or in what it recommended.

The new Department of Defense Small Business Innovation Research (SBIR) program resembles the Active Search Program to some degree. Its purpose is to stimulate and support small businesses to conduct high quality, innovative research and development related to important Defense-oriented scientific or engineering problems.

The BMD Advanced Technology Program is an active supporter of the SBIR program. In fact, 13 of the 50 Phase I SBIR awards for Army projects are for BMD Advanced Technology work and are currently being negotiated.

The chief difference between the Active Search Program and the SBIR Program is that under the Active Search Program, the Government was doing the technological window shopping, seeing what the private sector was involved in that might fit the Government's needs. Under the SBIR program, the Government issues a list of projects it is interested in, and the private sector does the window shopping.

While most of the formal pursuit of innovation in BMD is conducted on the Advanced Technology Program, the Systems Technology Program has its innings too, as I indicated earlier. Perhaps the best example is the program to evaluate Unconventional BMD Concepts. The BMD Program has been interested in unconventional concepts from its inception, particularly those which appear to promise an acceptable level of effectiveness and rapid deployability with simple, inexpensive technology. Heretofore, these concepts have been identified and examined on a rather cyclical but unsystematic basis. However, under the Systems Technology Program, a permanent group has been established to identify and evaluate Unconventional BMD Concepts, no matter how far-fetched they may seem at first glance. At present we are investing approximately $2 million a year in the effort. In the last year-and-a-half we have reviewed or evaluated more than 40 Unconventional BMD Concepts.

Although may of them are interesting, so far they all have at least one fatal flaw. Sometimes it is only the cost or time that would be involved to make them work effectively. Some of the concepts we have evaluated repeatedly over the years because, as the sophistication of readily available technology increases, their promise of simple, inexpensive effectiveness may be more easily realized. In any case, we shall remain open to examining anyone's unconventional concept for BMD, even if his name is Rube Goldberg.

What can be learned regarding high technology and innovation from the experiences I have recounted? I believe that the most important lessons are those of imagination, willingness to risk, patience, and dedicated resources. A little imagination is necessary to allow those of us in charge to believe there might be something in some sort of otherwise crazy scheme. Willingness to risk is necessary to keep us from deterring ourselves from taking a chance because the scheme might fail. Unwillingness to risk is a characteristic that all successful institutions must fight: the more successful they become, the more conservative they become. Patience is required to give something time to work if the promise still exists, even when it may have failed before. Most important though, are dedicated resources—both money and workforce. They prove to yourself and others that you are really serious about pursuing innovation in this high-technology world. After all, you are trying to direct the mind and productive capacity of man where perhaps none has gone before. Those are expeditions that are not easy for the backers or for the adventurers. But think of the payoffs that are possible.

I have appreciated the opportunity of appearing at this hearing, and I shall be happy to attempt to answer any questions you may have.

Senator HEFLIN. Well, thank you, sir. We appreciate your testimony.

As our final panel, we will have Mrs. Loretta Spencer, of the Research Park Board of the city of Huntsville, and Mr. Herschel Matheny, who is the president of Dynetics here in Huntsville.

Is this Cummings Park West? Well, go ahead, Mrs. Spencer.

STATEMENT OF LORETTA SPENCER, RESEARCH PARK BOARD, HUNTSVILLE, ALA.

Ms. SPENCER. What you have just received, I will say before I start my testimony, is brand new. It is our report from MCI, which we felt they were very well qualified. We looked at other engineering firms. That one has done our first plan developed in the city of Huntsville, which is new innovative housing, which is what we look for in the planning commission, a new way to house all the high tech companies.

Cummings Research Park in Huntsville is an outstanding example of how an industry-university-government partnership can originate and nurture a research park for the mutual advantage of all three. There are many variations of research parks defined by their tenant composition which can range from pure research and development parks through mixed use parks to those parks that are basically highly restrictive industrial parks.

Huntsville's Cummings Research Park falls in the middle category, because it combines research and development activities with light manufacturing and office uses. However, stringent zoning regulations ensure that the entire district maintains a pleasant, parklike setting with generous setbacks for the buildings, low density development, and attractive plantings.

Cummings Research Park is the second oldest mixed use research park in the Southeast and also the second largest in number of persons employed, being topped in both instances only by Research Triangle Park in North Carolina. A brief overview of how Cummings Research Park began and the plans for its future will illustrate how the industry-university-government partnership has contributed to its present success. And while Cummings has experienced a unique conceptual and developmental history that would not be applicable in other localities, it does provide valuable insights into those factors that determine the success or failure of such a venture.

The impetus for Huntsville's park arose during the late 1950's with the creation of NASA in 1958 and the establishment of the George C. Marshall Space Flight Center in Huntsville in 1960. Both the Marshall Space Flight Center and the Army Missile Command were headquartered at the Redstone Arsenal southwest of the city and both were in a position to let extensive Government contracts to private industry.

In 1961, two events led to the establishment of a research park district. First, Brown Engineering, a large aerospace contractor, purchased 150 acres of land west of Sparkman Drive to construct a new facility, and they subsequently sold part of this parcel at cost to similar companies working on Government contracts in order to foster the creation of a concentrated high technology area.

Second, in the same year, Dr. Werner Von Braun, the Director of Marshall Space Flight Center, recognized the need for an independent research facility to complement the work being conducted by NASA. Von Braun took his idea for such a facility to the Alabama Legislature, which authorized a $3 million bond issue, subsequently approved by the voters, to construct the University of Alabama in Huntsville Research Institute.

By 1963, the city government had designated approximately 4,000 acres for research park use, which included the UAH campus, and adopted zoning regulations to assure that development would proceed in an orderly and attractive fashion. The following year the Research Park Advisory Board was established by representatives of park tenants to oversee future development and planning.

Because this was an early research park and because it, along with everything else in Huntsville during the 1960's, developed at a tremendous speed due to the dramatic changes that were taking place here as a result of the space program, this original portion of the park was filled and the infrastructure built on a piecemeal basis. Nevertheless, by 1972 the park had attracted 24 tenants who had erected buildings totaling 2 million square feet of floor space and were employing some 7,200 persons.

Cummings Research Park came into existence because of the interaction of industry, which purchased the first tract of land, State government, which provided funding for a research institute and assisted in the practical development by building the necessary roads, city government, which took responsibility for providing zoning, regulations and the required infrastructure, and the university, which physically became part of research park and provided a home and staffing for the research institute.

In actuality, the university's associate with Huntsville's high-tech development goes even deeper. UAH came into being in 1950 to serve the specific needs of Huntsville's scientific and technological community. The first master's degrees were awarded in the early 1960's and the first undergraduate degrees followed in the late 1960's. This intimate involvement between the university and Huntsville's high-tech enterprises is further apparent from the high level of local financial support tendered the school by the people of the city, and in turn by the university's structuring of both its course offerings and its scheduling, which are designed to permit adults to pursue degree programs or take additional course work while holding a full-time job.

During the 1970's Huntsville suffered severe cutbacks when the boom ended as space exploration ceased to be a top priority industry of the Federal Government. Several high-tech companies closed their Huntsville operations and many highly paid, well educated, white collar persons left the city.

At the end of the decade, the community began to realize that to maintain the city's exceptional quality of life a major effort would have to be made to encourage new high-technology corporations to relocate here. A request to the planning commission in 1981 to rezone 1,000 acres of research parkland, and I might add for residential use, apartments, and commercial uses, prompted a reassessment of the city's goals for future development.

A study by the planning department revealed fewer than 150 acres of useable land remained on the east side of the district. Although there were over 2,000 acres available in the western portion, it was raw land and hence not attractive to high-tech companies.

Consequently, in 1982 the city of Huntsville appointed a research park board composed of government, university officials, and representatives of research park. The board was charged with planning for the expansion of the park and recruiting new businesses. The city, upon recommendation of the research park board, hired two consultant firms to study Huntsville's situation and make recommendations for a future course of action.

Furthermore, the city initiated a program of purchasing vacant land within the research park district for improvement and resale to prospective tenants. The board members visited other successful research parks to assess the competition and to begin recruitment of new firms.

The city is now in a position to aggressively compete for those companies looking for new sites. The two consultant reports are completed. The first, by MCI/Consulting Engineers of Nashville and Huntsville, is a land-use master plan for Cummings Research Park West, which consists of 2,200 acres west of Rideout Road.

Unlike the original portion of research park, which developed without any master plan, Research Park West will be totally planned before any land is sold. Drainage, lot layout, utilities, roads, and landscaping have all been designed to create an attractive environment providing those amenities required by high-tech companies. The State is assisting in this effort by building the Bradford Drive overpass that will connect the developed portion of the park with the new section.

The second report, prepared by Battelle Laboratories of Columbis, Ohio, addresses the question of which companies would be most desirable and realistic for Huntsville to acquire and outlines a marketing strategy for recruiting them.

The university has continued to be an active participant in this planning process by serving on the research park board and, even more importantly, by working to strengthen those academic programs in engineering, math, and the sciences that are crucial in serving as support systems for research park companies. Additional State funding is being sought to finance an expanded faculty and new, enlarged facilities and equipment so that increasing numbers of well-trained students can be graduated by the university.

Recognizing that the demands and priorities of high-tech companies are somewhat unique, the city government has acted to upgrade those city services that are critical to such firms when evaluating potential new location. A 5-year capital improvements budget, funded by a 1-cent increase in the city's sales tax, was adopted by the city council this fall. That will provide additional funds for the local school system, improve drainage throughout the city, relieve traffic congestion, and improve safety on selected streets, and finance the construction of three new fire stations, and the improvement of four city parks and six other recreational facilities.

In addition, the city planning department has just completed work on establishing new zoning regulations for Research Park West, which will be composed of two districts: A large, traditional mixed-use research park district and a smaller research park applications district. The latter will provide space for those operations that do not technically qualify as a research park land use, but which have natural ties to typical research park operations and would benefit from this close proximity.

The zoning regulations for Research Park West are more strict than are the regulations for the original portion of the park and reflect the increased control and protection that is desired by prospective tenants of such a park.

The local chamber of commerce, which receives some of its funding from the city, has been a major participant along with the research park board and the planning department throughout all of this background planning, and the chamber will continue to take a major role in recruiting those companies that have been targeted by the Battelle report as ideal candidates for Huntsville's research park. Two companies have already stated their intention to purchase tracts and construct facilities in Research Park West, and at least 20 other high-tech firms have expressed interest in locating there.

The 1982 report of the research park advisory board lists 34 companies and Government agencies, in addition to UAH, that have purchased land in Cummings Research Park. Thirty-eight buildings are already constructed, containing 2,900,000 square feet of floor space, for an assessed value of approximately $85 million, while 10,000 persons are employed in the park. UAH contributes another 500,000 square feet to the total floor space and adds 6,000 students to the number of persons who regularly use research park.

In summary, it is most apparent that Huntsville's Cummings Research Park has relied heavily on a strong, effective industry-Government partnership from its very beginnings. The present planning efforts to assure the successful future development of Research Park West has demonstrated the continued need for all three agencies to work together if any meaningful results are to accrue. However, in order for Huntsville to actually achieve this success, there must be additional and even stronger commitments from government at both the State and Federal levels.

Specifically, the Federal Government must make a financial investment in these ventures; existing Federal programs need to be expanded and new Federal programs need to be implemented. The demands of high-tech companies for fully developed land impose a severe hardship on communities which must make a sizable financial investment in land and infrastructure development before any benefits are received. The increasing demand by these companies for buildings already in place will only add to this burden.

The Federal Government could assist those communities that have demonstrated a willingness to undertake such commitments through increased local taxation and the purchase of land by entering into a development partnership with the community. The Federal Government could also ease these startup costs with grants specifically aimed at infrastructure installation. The costs incurred in supplying underground wiring, adequate roads, drainage, and master plans can be so substantial as to defeat a project before it gets underway.

The Federal Government can help sustain existing research parks by locating Federal agencies within such districts and by directing research funds and contracts to similarly located firms. Another way the Federal Government can assist in insuring the success of research parks is by its support of those university programs that already have an established connection with high tech and research park companies. Centers of excellence could be encouraged to develop strong science/engineering/computer programs that would serve to enhance the work being conducted by local high tech firms.

Finally, the Federal Government could provide a major assistance by offering support to embryonic high-tech companies. There were 20-million new jobs created during the last decade, of which 80 percent were directly attributable to high-tech companies less than 4 years old. This trend is expected to continue.

However, of the approximately 50,000 new business starts each year, roughly 80 percent fail within 3 years because of poor management, inadequate funding, or poor market analysis. Contrast this situation with the 90-percent success rate for those new business starts that are funded by venture capital companies.

In other words, the Government could aid new high-tech business starts, which account for the majority of new jobs created, by providing management and technical assistance, low-interest rate funding loans, and an environment conducive to such fledgling business operations.

In short, without a serious commitment on the part of the Federal Government, many worthy high-tech research parks are doomed to fail. No one agency, be it local government, industry, or university, can be solely responsible for developing strong research, parks that are a credit to their city and State. All three partners must work hand in hand if success is to result.

Senator **Heflin**. Mr. Matheny, we will be glad to hear from you now.

STATEMENT OF HERSCHEL A. MATHENY, PRESIDENT, DYNETICS, INC.

Mr. MATHENY. Mr. Chairman, it is a privilege to come before this committee, and I would like to point out that Dynetics is one of the companies that Ms. Spencer is talking about going into Research Park West, and will probably be one of the companies that will be starting immediately.

I will confine my remarks to about three primary areas: One—and this is the main purpose of my being here—is to define some of the activities of the Small Business High Technology Institute and some of our local activities associated with that organization. The second thing I will comment on is S. 1286, and I will take off on one point that Ms. Spencer mentioned, and that is some of the merits of the bond issues, et cetera, helping businesses and research park facilities.

First, the Small Business High Technology Institute was created just after Congress passed the Small Business Innovation Development Act of 1982, which is known as the SBIR. The initial operations of that organization were funded by a grant from the J. Howard Pew Trust Fund. Some of the activities of the organization are establishing a State innovation network, that is a network of volunteers, bringing together small high-tech businesses, scientific, professional, and academic personnel.

Under the plan, each State will have at least two cochairmen, and an overall network will approach approximately 200 people per State, depending on the population and an interest in the high-tech business.

The main purpose of this network is to assist the startup and growth of these small high-tech firms. The second activity we are doing is encouraging and persuading the small business investors to participate in the SBIR and work with those and other applicable technologies.

Third is to establish at least one joint interest Business-University Technology Council in each State to foster better relations between university faculty technology experts and small business high-tech firms.

Another activity is to set up a Small Business Technology Information Center to pass on pertinent basic scientific and applied technology data for use by small high-tech firms.

And the last category is establishing a standard technology classification code to complement the existing SIC codes, which inadequately classify emerging high technologies.

Now, locally, we have established a volunteer nonprofit organization which is the beginning of the State's network. Hopefully, all of this is going to be successful in terms of communication, particularly in the small business area. And we have already encouraged local businessmen, executives, lawyers, accountants, bankers, et cetera. And all of this has started a cooperative effort between this group, Government personnel, university personnel, and technical school personnel.

I mentioned the technical school personnel because in the high-tech business technical school personnel providing the technicians and semiskilled workers are just as important as some of the basic researchers once you start putting ideas into a product. So I think the technical schools, whether they are the technical college here at J. F. Drake or John C. Calhoun, are very important to the high-tech business in this area.

And the essential elements of success of any business is the strong research base that we are talking about; the labor force which we can get from research universities and the technical schools; and one thing that was also pointed out is a need for access to capital, a management team, and a cooperative community. We in Huntsville are fortunate that we have these elements.

Huntsville has always been in the technological forefront with technology of the Army and NASA here, and I will not define those. Many people have already.

We are also fortunate to have the two universities, UAH and Alabama A&M; and I have already mentioned the other technical schools. The only thing that may be missing from small business standpoint in Huntsville is venture capital, and that is one reason why the small business innovation research program is probably a good base of start-up for people to use as development money if they can receive one of the SBIR's awards from one of the agencies. That was the reason for concentration in that area.

I will make just a brief comment on S. 1286. I think it is a great idea. We need a catalyst to increase productivity in this country. In the interest of time, I will not go any further than that.

But I would like to point out an additional area that I think is critical, and I think becomes a patently annual thing under discussion, and that is the tax-exempt bond issues that are used to fund some of these facilities, particularly in research parks, and I understand there is legislation before Congress to modify some of the tax provisions. And I realize that it is subject to abuses, and I will be the first person to eliminate the abuses. However, I think some of us are very dependent on the bond issues for research parks. So I am trying to emphasize it.

The difference in the cost between a 75-percent prime rate loan versus a conventional rate makes it very prohibitive to establish facilities, and I am sure you are aware of that. I am just trying to point that out.

I think with all the environment we have here in Huntsville or anywhere else—in scientific aspects, the community support, and the industry base—we still have to have that support of the bond issues, or else we cannot get it done. It is just not economically feasible. So I want to strongly support that in any upcoming legislation.

That concludes my testimony, sir.

[The statement follows:]

STATEMENT OF HERSCHEL A. MATHENY, PRESIDENT, DYNETICS, INC.

It is a privilege to come before this Subcommittee on science, Technology and Space.

I'll confine my remarks to three primary areas: (A) Defining, in a general sense, the objectives of the Small Business High Technology Institute and our local activities associated with that organization; (B) Commenting on bill S. 1286 to establish a program to conduct research and development for improved manufacturing technologies and; (C) Discussing the merits of tax exempt bond issues in establishing facilities which create jobs.

A. Small Business High Technology Institute.—Shortly after Congress passed the Small Business Innovation Development Act of 1982, the Small Business High Technology Institute was founded. Initial operations have been funded by a grant from the J. Howard Pew Trust Fund. Some of the Institute's activities are:

1. Establishment of innovation networks of volunteers in every State by bringing together small high-technology businesses, scientific, professional and academic leaders. Each State has at least two co-chairmen and the overall network could approach 200 for each State. The main purpose of this network is to assist the start-up and growth of emerging small business, high-tech companies.
2. To provide encouragement and persuasion to the best small high technology firms to participate in the small business innovation research (SBIR) program.
3. The establishment of at least one joint small business-university technology council in each State to foster better relations between university faculty technology experts and small business high-tech firms.
4. To set up a small business technology information system to pull together pertinent basic science and applied technology data for use by small high-tech firms.
5. Development of a standard technology classification code to complement the existing SIC codes which inadequately classify emerging technologies.

Locally, we have established a volunteer non-profit organization which is the beginning of this State's network and it will be expanded within the State. Included in this group are small business executives, lawyers, accountants, and bankers. Cooperation is being established between this group, Government personnel, university personnel and technical school personnel.

The essential elements of success in the high technology business are: (A) A strong scientific research base, (B) A trained labor force, (C) Access to venture capital, (D) A suitable management team, and (E) Cooperative community, State, and national leaders.

We in Huntsville, are fortunate. We already have most of these elements in existence. Huntsville has been in the scientific and technological forefront for years with the State-of-the-art advances of the U.S. Army and NASA. We are fortunate to have two universities, Alabama A&M, and the University of Alabama in Huntsville. In addition, we have J.F. Drake Technical College which is an excellent source for Technians. Furthermore, we have community leaders in the city, county, chamber of commerce, industrial board, businesses, industry and government who work together for achievement of goals.

The only element missing for the small business in Huntsville is a venture capital source. The small business high technology institute thinks that the SBIR program can provide relief to small high-tech business in that area.

B. Bill S. 1286—Research and development for improved manufacturing techniques.—We need something to provide a catalyst to increased productivity. The provisions of this bill appear to serve that purpose to some degree. Therefore, I favor it. The funding levels may be low, but it represents a start.

C. Bond issues.—I understand that there is legislation before Congress to modify the tax provisions of bond issues utilized in facility acquisition. It is realized that there have been abuses in this program and I would be the first person to urge you to eliminate those abuses. However, any restrictions which hamper the acquisition of research, development, and manufacturing facilities and equipment can only result in continued high unemployment levels. The difference in costs between a 75 percent of prime interest rate and a conventional loan is significant as you know. Conventional loans at today's rates will be prohibitive to investment by most firms and particularly the small business firm.

Delays in passage of a bill and the delays caused by interpretation will compound the delays in our economic recovery. Even anticipation of new legislation results in delays by firms in planning new facilities.

I urge you to promptly act on simplified legislation which promotes the development of research parks and industrial facilities in this country.

Senator HEFLIN. I do not know. I will have to go back and recall my days when I was a practicing lawyer as to whether or not you qualify. But Alabama had some rather intriguing, interesting, and broad, liberal bond issues for plants under the Cater Act and the Wallace Act.

Mr. MATHENY. That is correct.

Senator **HEFLIN**. By which you entered into long-term leases. You did not have to pay any ad valorem tax other than the—well, it was a lease basis.

Mr. **MATHENY**. Correct.

Senator **HEFLIN**. There was no ad valorem taxes, and then the bonds were issued, and they were income tax free.

Mr. **MATHENY**. That is correct.

Senator **HEFLIN**. Because the industrial development bonds had been limited and restrictive to some degree.

Do high tech areas of which you are talking—would they qualify in that type of a bond issue?

Mr. **MATHENY**. Yes, sir, in the environment we have here as a research and development facility as they exist today. Now, in particular, I am not sure of the Wallace and Cater Act, but under the research and development provisions of the existing bond laws—are you familiar with those?

Ms. **SPENCER**. [Nods affirmatively.]

Mr. **MATHENY**. My understanding is that the Industrial Board will only issue bonds to research, development and manufacturing type facilities for this park.

Senator **HEFLIN**. Of manufacturing facilities?

Mr. **MATHENY**. Yes, sir, within that restriction. It is not authorized to issue bonds on office buildings, things of that sort. So I am speaking only——

Senator **HEFLIN**. In some places they build a McDonald's hamburger place with those kind of bond issues and got a lot of criticism for it.

Mr. **MATHENY**. Well, that is true.

Senator **HEFLIN**. I do not know what the status of that situation——

Mr. **MATHENY**. I think most of the high tech firms are R&D or manufacturing, yes, sir. So within those provisions, they are qualified. At least I hope so.

Senator **HEFLIN**. Well, it is an interesting industry you have got here, and this Cummings Research Park West—just browsing through it and thumbing through it as we go along, it is most interesting.

What is your unit that is acquiring the land and will be doing the—putting the restrictive covenants on all of this?

Ms. **SPENCER**. The city.

Senator **HEFLIN**. It is the city?

Ms. **SPENCER**. Uh-huh.

Senator **HEFLIN**. I did not know if you had a separate——

Ms. **SPENCER**. Not yet. We are at a completion point, so we are at a completion making point as to whether it will be a board, you know, doing it, because the city council and the mayor have authorized the sale of the land and acquisition of additional land.

Senator **HEFLIN**. Do you intend to go more by restrictive covenants as oppposed to zoning? Is that too technical an issue to get into?

Ms. **SPENCER**. I will let my authority get into that. It is a combination, as I understand it.

Senator **HEFLIN**. It is a combination?

Mr. **MATHENY**. Yes.

Senator HEFLIN. Sometimes it may be restrictive covenants that are mighty hard to change; and on the other hand, sometimes zoning gets too much into politics and gets changed too rapidly relative to matters.

Ms. SPENCER. Our main concern is at the prime location that it is within two major highways that there not be anything done to deteriorate the area and that all of it be encompassed at one time.

You mentioned earlier about the foresight of expanding parks. Well, that is what happened to us in Huntsville, was to have that foresight or lose the land and never have the land to do it, except in this one area.

Senator HEFLIN. And this would be an additional 2,200 acres?

Ms. SPENCER. Correct. And there is adjacent—some adjacent parcels of land that are being considered right now for other uses, but they would be compatible uses, which might have some trucking in it that we would like to restrict warehousing in this new park. Aesthetics are very important and your first impression of when you bring anyone in from out of town to look at your area.

Senator HEFLIN. Well, I really think that the Huntsville Research Park story and its success has not been told. It is probably the best-kept secret in the country as compared to the others. You are talking about the Silicon Valley and talking about the Triangle and these things. But really, basically, the Cummings Research Park has had a marvelous success and probably developed more rapidly than any other of them at a particular time.

Anything else you wanted to add to this?

Mr. GILLILAND. I would just like to pursue something you said, Mrs. Spencer, talking about the role of the Federal Government and how they can assist research parks. Have you envisioned how that would be created and established? Have you got some thoughts on that that you would like to share?

Ms. SPENCER. Not offhand. I just feel like that is just a potential that has not been developed in working with the Federal Government when they said—unfortunately, I did not prepare too far in advance for this, but I feel like the continuing tie because we have seen what local can do and what the State can come through on it; and we feel like you, your input in locating and working with us—these higher opportunities is the main thing.

Senator HEFLIN. All right. We may want to submit some questions later on.

Birmingham is interested, too, in a research park. They envision the cooperation of all of the universities of the State and some cooperation with the research park here in Huntsville as they proceed. I can foresee that this matter of material processing in space could develop into a tremendous industry some day. I mean, if it develops, as it appears right now, and with the strengths that we have in Alabama in metalurgy and medicine and health-related areas, there could be a great deal of cooperation; there could be a reason for a lot of cooperation to exist in various places, particularly between Marshall, the medical school, and certain types of engineering schools dealing with metalurgy, all of this, and something to be explored into being developed here.

We just do not know where we are going in materials processing. It is a brand new field. The experiments are going on in space right now, but we in Alabama can get in the forefront of that, and we might become the leading center for this of the world. And it is a real challenge, and it is something to be considered on which to work cooperatively.

The two most promising fields today are in the areas of pharmaceuticals and metalurgy. We have all of that here in Alabama, and I hope that that can be pursued.

Well, we appreciate your testimony and appreciate everybody being here. This will conclude the hearing.

[Whereupon, at 3:25 p.m., the subcommittee was adjourned.]

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